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# FM 5-25

DEPARTMENT OF THE ARMY FIELD MANUAL

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# EXPLOSIVES AND DEMOLITIONS

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HEADQUARTERS, DEPARTMENT OF THE ARMY

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FIELD MANUAL
No. 5–25

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *5 February 1971*

# EXPLOSIVES AND DEMOLITIONS


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# CHAPTER 1

# DEMOLITION MATERIALS

## Section I. INTRODUCTION

### 1–1. Purpose and Scope

*a.* This manual is a guide in the use of explosives in the destruction of military obstacles, and in certain construction projects. The material includes information on—

(1) Types, characteristics, and uses of explosives and auxiliary equipment.

(2) Preparation, placement, and firing of charges.

(3) Charge calculation formulas.

(4) Deliberate and hasty demolition methods for use in the forward zone.

(5) Safety precautions.

(6) Handling, transportation, and storage of explosives.

(7) Use of expedient demolition charges.

*b.* The contents of this manual are applicable to nuclear and nonnuclear warfare.

### 1–2. Comments

Users of this manual are encouraged to submit recommended changes and comments to improve the manual. Comments should be keyed to the specific page, paragraph, and line of text in which the change is recommended. Reasons will be provided for each comment to insure understanding and complete evaluation. Comments should be prepared using DA Form 2028 (Recommended Changes to Publications) and forwarded direct to the Commandant, U.S. Army Engineer School, Fort Belvoir, Virginia 22060.

### 1–3. Military Demolition

Military demolition is the destruction by fire, water, explosive, mechanical, or other means of areas, structures, facilities, or materials to accomplish a military objective. Demolitions are explosives used for such purposes. Demolitions have offensive and defensive uses; for example, the removal of enemy barriers to facilitate the advance and the construction of friendly barriers to delay or restrict enemy movement.

## Section II. MILITARY EXPLOSIVES

### 1–4. Definitions

*a. Explosives.* Explosives are substances that, through chemical reaction, violently change to a gaseous form and release pressure and heat equally in all directions. Explosives are classified as low or high according to the *detonating velocity* or speed (in meters or feet per second) at which this change takes place and other pertinent characteristics, such as their shattering effect.

*b. Low Explosives.* Low explosives *deflagrate* or change from a solid to a gaseous state relatively slowly over a sustained period (up to 400 meters or 1300 feet per second). This characteristic makes low explosives ideal where a pushing or shoving effect is required. Examples are smokeless and black powders.

*c. High Explosives.* The change in this type explosive to a gaseous state—detonation—occurs almost instantaneously at 1,0000 meters per second (3,280 feet per second) to 8500 meters per second (27,888 feet per second), producing a shattering effect upon the target. High explosives are used where this shattering effect is required—in certain demolition charges and in charges in mines, shells, and bombs.

*d. Relative Effectiveness Factor.* Explosives vary not only in detonating rate or velocity (feet per second or meters per second), but also in other characteristics, such as density and

energy production, that determine their effectiveness for cutting, breaching or cratering charges. As most military demolitions involve cutting or breaching, the amount of explosive used is adjusted by a relative effectiveness factor, which is based upon the *brisance* or *shattering effect* of the explosive in relation to that of TNT. The shattering effect (brisance) of a high explosive is related to its detonating velocity; for example, TNT, with a detonating velocity of 6,900 meters per second, has a relative effectiveness factor or 1.00, while Composition C4, with a detonating velocity of 8,040 meters per second, has a relative effectiveness factor of 1.34 (table 1–1).

*e. Cratering Effect.* The cratering effect of high explosives is dependent upon its total energy content, which determines the amount of energy available to throw the broken material from the crater. The shattering effect (rate of detonation) is not directly related to this effect. In fact, low brisance explosives are generally better in cratering ability. Therefore, the effectiveness of an explosive as a cratering charge is not adjusted by the relative effectiveness factor. As the blasting of road craters or ditches normally requires the use of large amounts of explosives, an ammonium nitrate based cratering charge has been adopted as a standard cratering charge because its cratering effect is comparable to other military explosives and it is relatively inexpensive.

## 1–5. Characteristics of Military Explosives

*a.* Explosives suitable for use in military operations have certain properties or characteristics required for their selection and standardization. These are—

(1) Produced from readily available raw materials and be inexpensive to manufacture.

(2) Relative insensitivity to shock or fric-

*Table 1–1. Characteristics of Principal U.S. Explosives Used for Demolition Purposes*

| Name | Principal uses | Velocity of detonation (meters/sec) (feet/sec) | Relative effectiveness as a breaching charge (TNT= 1.00) | Intensity of poisonous fumes | Water resistance |
|---|---|---|---|---|---|
| Ammonium Nitrate | Demolition charge, and composition explosives. | 2,700 mps, 8,900 fps | ---- | Dangerous | None. |
| PETN | Detonating cord, blasting caps, and demolition charge. | 8,300 mps, 27,200 fps | 1.66 | Slight | Excellent. |
| RDX | Blasting caps, composition explosives. | 8,350 mps, 27,400 fps | 1.60 | Dangerous | Excellent. |
| TNT | Demolition charge, and composition explosives. | 6,900 mps, 22,600 fps | 1.00 | Dangerous | Excellent. |
| Tetryl | Booster charge and composition explosives. | 7,100 mps, 23,300 fps | 1.25 | Dangerous | Excellent. |
| Nitroglycerin | Commercial dynamites. | 7,700 mps, 25,200 fps. | 1.50 | Dangerous | Good. |
| Black powder | Time blasting fuse. | 400 mps, 1,300 fps | 0.55 | Dangerous | Poor. |
| Amatol 80/20 | Bursting charge. | 4,900 mps, 16,000 fps | 1.17 | Dangerous | Very poor. |
| Composition A3 | Booster charge and bursting charge. | 8,100 mps, 26,500 fps | ---- | Dangerous | Good. |
| Composition B | Bursting charge | 7,800 mps, 25,600 fps | 1.35 | Dangerous | Excellent. |
| Composition C3 | Demolition charge | 7,625 mps, 25,000 fps | 1.34 | Dangerous | Good. |
| Composition C4 | Demolition charge | 8,040 mps, 26,400 fps | 1.34 | Slight | Excellent. |
| Tetrytol 75/25 | Demolition charge | 7,000 mps, 23,000 fps | 1.20 | Dangerous | Excellent. |
| Pentolite 50/50 | Booster charge and bursting charge. | 7,450 mps, 24,400 fps | ---- | Dangerous | Excellent. |

tion, yet able to be positively detonated by easily prepared initiators.

(3) Shattering effect (brisance) and potential energy adequate for the purpose.

(4) Stability adequate to retain usefulness for a reasonable time when stored in any climate at temperatures between −80° F. and +165° F.

(5) High density (weight per unit of volume).

(6) Suitability for use under water or in damp climates.

(7) Minimum toxicity (poisonous effects) when stored, handled and detonated.

(8) Convenient size and shape for packaging, storage, distribution, handling and emplacing by troops.

(9) High energy output per unit of volume.

*b.* The detonation or burning of all explosives produces poisonous fumes. The chemicals used in explosives are, in themselves, poisonous. For these reasons personnel should be especially cautioned against inhaling fumes or injesting explosives. When explosives are used in closed areas or underground, adequate time must be allowed for the fumes to dissipate before investigation. Explosives should be carefully controlled to prevent diversion to other than the intended purpose, i.e., burning as a source of heat or cooking.

*c.* Since explosives contain their own oxidizer, burning explosives cannot be extinguished by smothering. Whenever explosives burn there is a hazard of possible detonation. Personnel should not attempt to extinguish burning explosives without professional advice and assistance.

## 1–6. Selection of Explosives

The explosives for a particular purpose generally are selected on the basis of their relative power. However, all the characteristics listed in paragraph 1–5 must be considered when selecting the most suitable explosive for a particular demolition project. For detailed information and characteristics of military explosives see TM 9–1300–214; however, table 1–1 herein does contain significant information regarding many of the explosives described in the remainder of this section.

## 1–7. Ammonium Nitrate

Ammonium nitrate is the least sensitive of military explosives and must be initiated by a booster charge to successfully detonate. Because of its low sensitivity ammonium nitrate is widely used in composite explosives where it is combined with a more sensitive explosive (see para 1–14, 1–33, and 1–35). Because of its low detonating velocity, ammonium nitrate is not suitable for cutting or breaching charges. Because of its cratering effect and low cost, ammonium nitrate is used chiefly in cratering and ditching charges. It is widely used commercially in quarrying. Ammonium nitrate is extremely hygroscopic (will pick up moisture in the air) and must be packed in an airtight container. Ammonium nitrate or composite explosives containing ammonium nitrate are not suitable for use under water unless packaged in a waterproof container or detonated immediately after emplacement.

## 1–8. Pentaerythrite Tetranitrate (PETN)

Pentaerythrite Tetranitrate or PETN is highly sensitive and is one of the most powerful military explosives, comparable in force to RDX and nitroglycerin. PETN is used in boosters, detonating cord, and some blasting caps. It is also used in composite explosives with TNT (para 1–21) or with nitrocellulose as a demolition charge, such as the M118 demolition charge. PETN is nearly insoluble in water and may therefore be used in underwater demolitions.

## 1–9. RDX (Cyclonite)

RDX is highly sensitive and brisant (great shattering effect) and is one of the most powerful military explosives. RDX is used alone as the base charge in the M6 electric and M7 nonelectric blasting caps. When it is desensitized it is used as a subbooster, booster, bursting charge and demolition charge. The principal use of RDX is in the composite explosives such as composition A-, B-, C-type explosives (para 1–15 through 1–19).

## 1–10. Trinitrotoluene (TNT)

TNT is the most common military explosive and alone or as part of a composite explosive is widely used as a booster charge, bursting charge and demolition charge. It is used as a standard explosive against which other military high explosives are rated.

## 1–11. Tetryl

Tetryl is used alone as a booster charge and

also in some composite explosives as a bursting or demolition charge. Tetryl is more sensitive and more powerful than TNT; however, tetryl and composite explosives containing tetryl are being replaced by RDX and PETN based explosives which are more powerful and brisant.

### 1–12. Nitroglycerin

Nitroglycerin is one of the most powerful high explosives, comparable to RDX and PETN, and is used as the explosive base for commercial dynamites (see para 1–35). Nitroglycerin is highly sensitive and is affected by extreme temperatures. Because of its sensitivity and the difficulty in handling nitroglycerin, it is not used in military explosives, and commercial dynamites are not used in combat areas.

### 1–13. Black Powder

Black powder is the oldest explosive and propellant known. It is a composite made of potassium or sodium nitrate with charcoal and sulfur. Black powder is used in time fuse and some igniters and detonators.

### 1–14. Amatol

Amatol is a mixture of ammonium nitrate and TNT and has been used as a substitute for TNT as a bursting charge. 80–20 amatol (80 percent ammonium nitrate and 20 percent TNT) is used in some older bangalore torpedoes. Because amatol contains ammonium nitrate it is hygroscopic and must be stored in an airtight container. If properly packaged, amatol may be stored for long periods of time with no change in sensitivity, brisance, or stability.

### 1–15. Composition A3

Composition A3 is a composite explosive containing 91 percent RDX and 9 percent wax which coats the RDX particles, desensitizes them, and acts as a binder. Composition A3 is used as a booster charge in some newer shaped charges and bangalore torpedoes. It is also used as the main charge in High Explosive Plastic (HEP) projectiles.

### 1–16. Composition B

Composition B is a composite explosive containing approximately 60 percent RDX, 39 percent TNT, and 1 percent wax. It is more sensitive than TNT. Because of its shattering power and high rate of detonation, composition B is used as the main charge in shaped charges.

### 1–17. Composition B4

Composition B4 contains 60 percent RDX, 39.5 percent TNT and 0.5 percent calcium silicate. It is used as the main charge in newer models of bangalore torpedoes and shaped charges.

### 1–18. Composition C2 and C3

Composition C2 is a composite explosive containing 80 percent RDX and 20 percent explosive plasticizer. This explosive plasticizer contains TNT and other explosive ingredients. Composition C2 was replaced by composition C3 which contains 77 percent RDX and 23 percent explosive plasticizer containing TNT, tetryl, nitrocellulose and other explosive ingredients. Both compositions are pliable and moldable at temperature between −20° F. and +125° F. Because of their high rate of detonation and brisance both compositions are used as demolition charges. Being insoluble in water, block demolition charges of composition C2 and C3 are suitable for underwater demolition. Storage of composition C2 and C3 at temperatures above 120° F. or excessive molding may cause some oils and gases to be exuded from C2 and C3.

### 1–19. Composition C4

Composition C4 is a composite explosive containing 91 percent RDX and 9 percent nonexplosive plasticizers. Composition C4 will eventually replace composition C3 as a demolition charge and is also used as a burster charge. It is more brisant than composition C3 and is moldable over a wider range of temperatures (−70° F. to +170° F.); it is more stable, and is less subject to erosion by water when used for underwater demolitions.

### 1–20. Tetrytol

Tetrytol is a composite explosive of tetryl and TNT (75 percent tetryl and 25 percent TNT) and is used as a demolition charge. Other mixtures are used as burster charges. Tetrytol is more powerful and brisant than TNT and is less sensitive than tetryl.

### 1–21. Pentolite

Pentolite is a mixture of PETN and TNT. A mixture of 50–50 Pentolite (50 percent PETN

and 50 percent TNT) because of its high power and detonating rate, is used as a booster charge in certain models of shaped charges.

### 1–22. Dynamites

Most dynamites, with the notable exception of military dynamite (para 1–23), contain nitroglycerin plus varying combinations of absorbents, oxidizers, antacids and freezing point depressants. Dynamites vary greatly in strength and sensitivity depending upon, among other factors, what percentage of nitroglycerin they contain. Dynamites are used for general blasting and demolitions, to include land clearning, cratering and ditching, and quarrying. For additional information see paragraph 1–35.

### 1–23. Military Dynamite

Military dynamite is a composite explosive which contains 75 percent RDX, 15 percent TNT, and 10 percent desensitizers and plasticizers. It is equivalent in strength to 60 percent commercial dynamite. It contains no nitroglycerin and is therefore more stable and safer to store and handle than commercial dynamite. For further information see paragraph 1–34.

### 1–24. Foreign Explosives

*a. Types.* Explosives used by foreign countries include TNT, picric acid, amatol, and guncotton. Picric acid has characteristics like TNT except that it corrodes metals and thus forms extremely sensitive compounds. A picric acid explosive in a rusted or corroded container must not be used; in fact, it should not be handled in any way, except to move it very carefully to a safe disposal area or location for destruction.

*b. Uses.* Explosives of allied nations and those captured from the enemy may be used to supplement standard supplies. Such explosives, however, should be used only by expert demolitionists and then only according to instructions and directives issued by theater commanders. Captured bombs, propellants, and other devices may be used with U.S. military explosives for larger demolition projects, such as pier, bridge, tunnel and airfield destruction (app C). Most foreign explosive blocks have cap wells large enough to receive U.S. military blasting caps. These blasting caps, when used to detonate foreign explosives, should be test fired to determine their adequacy before extensive use as these explosives may be less sensitive than U.S. types.

## Section III. BLOCK DEMOLITION CHARGES

### 1–25. Block Demolition Charges

Block demolition charges are prepackaged high explosive charges used in general demolition operations such as cutting, breaching, and cratering. They are composed of the high explosives TNT, tetrytol, composition C series, and ammonium nitrate. They are made in the form of rectangular blocks, with the exceptions of the 40-pound ammonium nitrate block demolition charge and the ¼-pound TNT block demolition charge, which are made in cylindrical form. The various block charges available are described in table 1–2 and paragraphs 1–26 through 1–33. For detailed information and characteristics of demolition charges and accessories see TM 9–1375–200.

### 1–26. Charge, Demolition: Block, TNT, 1/4-, 1/2- and 1-Pound

*a. Characteristics.* TNT demolition blocks (fig 1–1) are issued in three sizes as listed in table 1–2. The ¼-pound block is issued in a cylindrical waterproof olive-drab cardboard container; and the ½-pound and 1-pound blocks are issued in similar containers. All three have metal ends with a threaded cap well in one end. Additional characteristics are listed in table 1–2.

*b. Uses.* TNT block demolition charges are standard demolition charges and are used for all types of demolition work. However, the ¼-pound charge is used primarily for training purposes.

*c. Advantages.* TNT demolition charges have a high detonating velocity, are stable, are relatively insensitive to shock or friction, and have excellent water resistance. They also have a convenient size, shape and packaging.

*d. Limitations.* TNT block demolition charges cannot be molded and are difficult to use on an irregular shaped target. TNT is not recommended for use in closed spaces because its explosion produces poisonous gases.

### 1–27. Charge, Demolition: Block M2 (2½-Pound, 75–25 Tetrytol)

*a. Characteristics.* The M2 block demolition charge (fig 1–2) is a block of 75–25 tetrytol

*Table 1-2. Characteristics of Block Demolition Charges*

| Nomenclature | Explosive | Weight | Size (inches) | Detonating velocity (meters/sec) (feet/sec) | Relative effectiveness factor | Packaging and total weight |
|---|---|---|---|---|---|---|
| CHARGE, DEMOLITION: Block (TNT) | TNT | ¼ lb. | 1½ D. x 3½ L. | 6,900 mps, 22,600 fps | 1.00 | 200 per wooden box. wt: 79 lbs. |
| | | ½ lb. | 1¾ x 1¾ x 3¾ | | | 96 per wooden box. wt: 65 lbs. |
| | | 1 lb. | 1¾ x 1¾ x 7 | | | 48, 50 or 56 per wooden box. wt: 80 lbs. |
| CHARGE, DEMOLITION: M2 block. | 75/25 tetrytol, w/tetryl booster. | 2½ lb. | 2 x 2 x 11 | 7,000 mps, 23,000 fps | 1.20 | 8 per haversack, 2 haversack (16 chg) per wooden box box. wt: 57 lb. |
| CHARGE, DEMOLITION: M3 block. | Comp. C-2 | 2¼ lb. | 2 x 2 x 11 | 7,650 mps, 25,100 fps | 1.34 | 8 per haversack, 2 haversack (16 chg) per wooden box. wt: 45 lb. |
| | Comp. C-3 | | | 7,625 mps, 25,000 fps | | |
| CHARGE, DEMOLITION: M5A1 block. | Comp. C-4 | 2½ lb. | 2 x 2 x 11¾ | 8,040 mps, 26,400 fps | 1.34 | 1 per plastic bag, 24 bags (24 chg) per wooden box. wt: 80 lb. |
| CHARGE, DEMOLITION: M112 block. | Comp. C-4 | 1¼ lb. | 1 x 2 x 11 | 8,040 mps, 26,400 fps | 1.34 | 1 per plastic bag, 30 bags (30 chg) per wooden box. wt: 48 lb. |
| CHARGE, DEMOLITION: M118 block. | PETN or RDX based. | Block: 2 lb. Sheet: ½ lb. | Block: 1¼ x 3¼ x 12½ Sheet: ¼ x 3 x 12 | 7,190 mps, 23,600 fps | 1.14 | 1 block (4 sheets) per plastic wrapper, 20 blocks per wooden box. wt: 52 lb. |
| CHARGE, DEMOLITION: M186 roll. | PETN or RDX based. | 25 lb. (½ lb per foot) | ¼ in. x 3 in. x 50 ft. | 7,190 mps, 23,600 fps | 1.14 | 1 roll per canvas bag, 3 bags per wooden box: wt: 115 lb. |
| CHARGE, DEMOLITION: Ammonium nitrate. | Ammonium nitrate with TNT booster. | 43 lbs. | 7 D. x 24 L. | 3,400 mps, 11,000 fps | 0.42 | 1 metal container per wooden box. wt: 52 lb. |

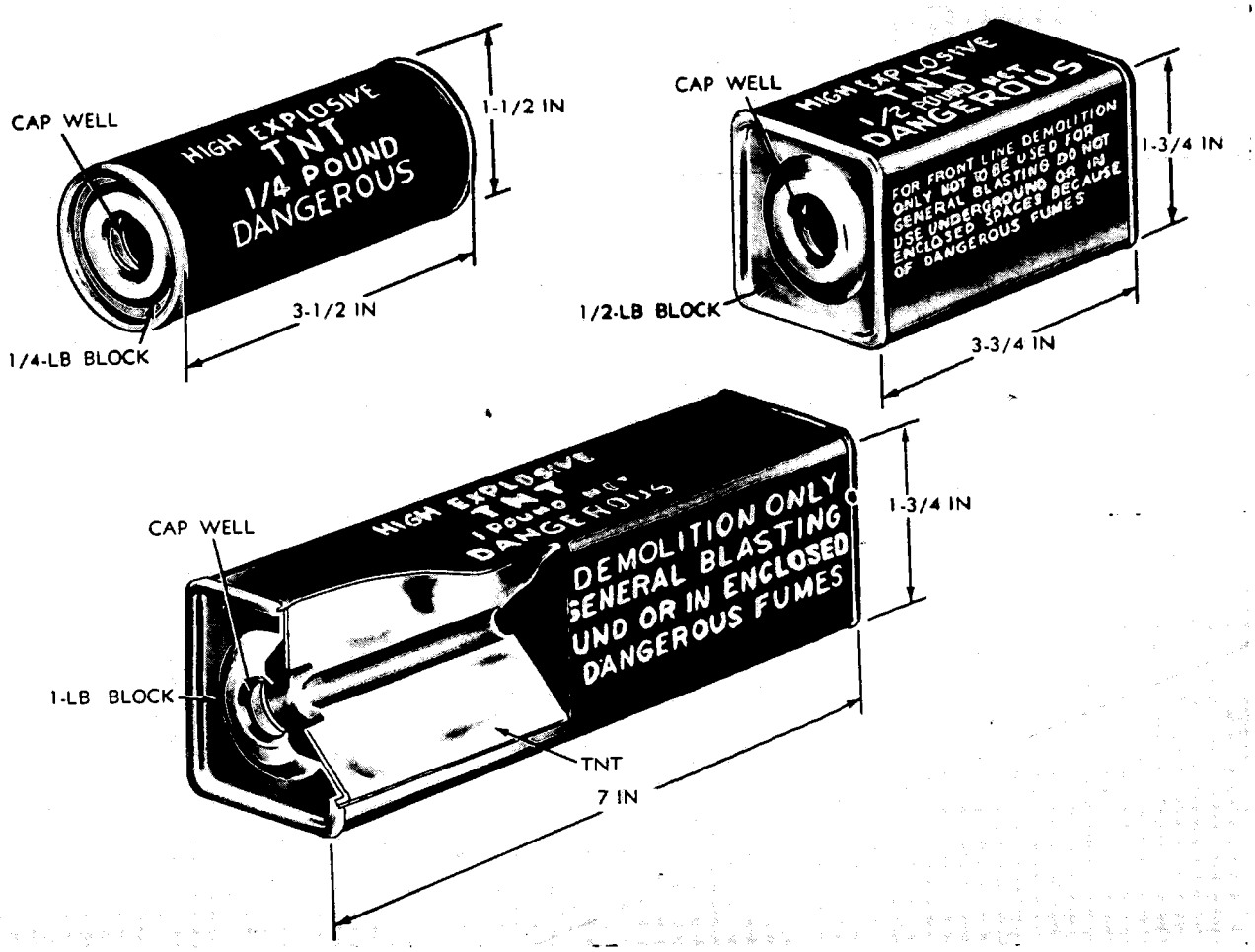



*Figure 1–1. TNT block demolition charges.*

with a tetryl booster pellet and a threaded cap well cast in each end. Each block is wrapped in olive-drab, asphalt-impregnated paper. Additional characteristics are listed in table 1–2.

*b. Uses.* Tetrytol is more powerful and more brisant than TNT and is effective as a cutting or breaching charge and may be used as an alternate to TNT in general demolition work. Tetrytol demolition charges are being eliminated, and no M2 demolition blocks will be issued when present stocks are exhausted.

*c. Advantages.* Because of its packaging (in haversacks) the M2 demolition charge is well suited for assault demolitions. Tetrytol is only slightly soluble in water and the M2 block may be used as an underwater demolition charge.

*d. Limitations.* Tetrytol blocks must have the pure tetryl booster to insure detonation and can therefore be broken into only two pieces. The tetryl booster is more sensitive to impact than tetrytol or TNT and may be detonated by small arms fire. The M2 block of tetrytol is brittle and shatters easily if dropped or struck.

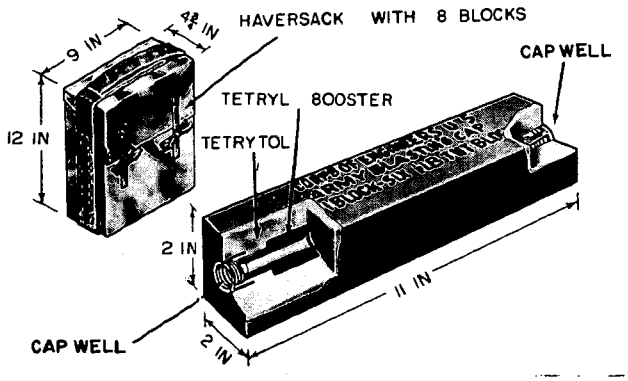



*Figure 1–2. M2 block demolition charge, tetrytol.*

## 1–28. Charge, Demolition: Block, M3 2 1/4-Pound, Composition C2 or Composition C3)

*a. Characteristics.* The M3 block demolition charge (fig 1–3) is available in either composi-

tion C2 or C3. The M3 block is enclosed in glazed paper which is perforated around the middle for ease in breaking open. The M3 block does not have a cap well. Composition C2 and C3 are pliable and may be molded at temperatures between −20° F. and +125° F. Additional characteristics of the M3 block demolition charge are listed in table 1–2.

*b. Uses.* Composition C2 and C3 are similar and may be used interchangeably. They are more powerful than TNT and of about the same sensitivity. Because of their plastic nature and high power these explosives are suitable for cutting steel or irregular shaped targets, as they may be molded to fit the shape of the target and thus can achieve better contact with resulting high demolition efficiency. Being insoluble in water, block demolition charges of composition C2 and C3 are suitable for underwater demolition, if enclosed in a container or wrapping to prevent erosion by running water. These explosive compositions are being replaced by composition C4 demolition charges but may be used as an acceptable alternate to composition C4.

*c. Advantages.* These explosives are moldable and may be cut and molded to proper size and shape to fit all targets.

*d. Limitations.* Below −20° F. composition C2 and C3 become brittle and above +125° F. they exude some of their oils and become buttery. They emit gases which will cause sickening headaches.

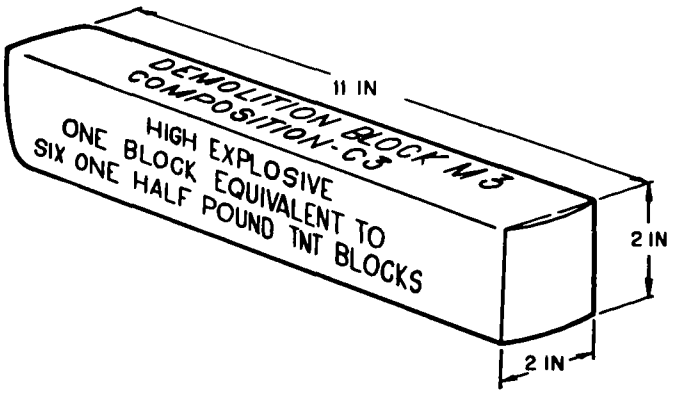



*Figure 1–3. M3 block demolition charge.*

## 1–29. Charge, Demolition: Block, M5A1 (2 1/2-Pounds, Composition C4)

*a. Characteristics.* The M5A1 block demolition charge (fig 1–4) is of explosive composition C4 encased in a clear white plastic container with a threaded cap recess in each end. Bulk explosive is obtained by cutting open the plastic container. Composition C4 is moldable between −70° F. and +170° F. Additional characteristics are listed in table 1–2.

*b. Uses.* M5A1 block demolition charges are used in almost all types of demolition work, and primarily for cutting and breaching. Because of its moldability and high brisance composition C4 is ideally suited for steel cutting charges and for cutting irregular shaped targets. Composition C4 is insoluble in water and may be used for underwater demolitions.

*c. Advantages.* Composition C4 is more powerful than composition C3. It is moldable over a broader range of temperatures, is more stable, is less sticky, and is less subject to water erosion underwater. Because of its plasticity it may be cut and molded to conform to the shape of the target.

*d. Limitations.* The white color of the composition C4 in the M5A1 block is difficult to camouflage. Running water will erode composition C4 if not protected.

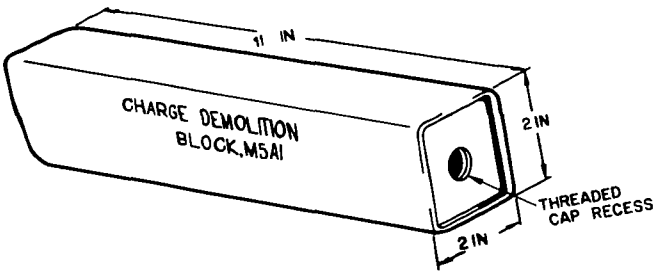



*Figure 1–4. M5A1 block demolition charge.*

## 1–30. Charge, Demolition: Block M112 (Composition C4, 1 1/4-Pounds)

*a. Characteristics.* The M112 block demolition charge (fig 1–5) is an improved version of the conventional composition C4, M5A1 block demolition charge (para 1–29) and replaces the M5A1 block as the standard item of issue. The M112 block demolition charge consists of 1¼ pounds of composition C4 packed in a mylar-film container with a pressure-sensitive adhesive tape on one surface, protected by a peelable paper cover. Additional characteristics of the M112 block are listed in table 1–2.

*Note.* The composition C4 in some M112 blocks is colored dull-gray and packed in a clear mylar-film container; in blocks of recent manufacture, the composition C4 is white in color and packed in an olive-drab mylar-film container.

*b. Uses.* The M112 block demolition charge is used in the same manner as the M5A1 block demolition charge. This charge is ideally suited for cutting charges as the adhesive backing allows the charge to be attached to any relatively flat, dry surface above freezing.

*c. Advantages.* The M112 block demolition charge is of a more efficient shape, and handier size. It is easily attached to the target. It may be cut and molded to fit irregular shaped targets. The color of the wrapper aids in camouflage.

*d. Limitations.* Odd weight makes calculation of charge weights difficult. Adhesive tape will not adhere to wet surfaces or frozen surfaces.

***Warning.* Composition C2, C3 and C4 explosives are poisonous and dangerous if chewed or ingested, and their detonation or burning produces poisonous fumes.**

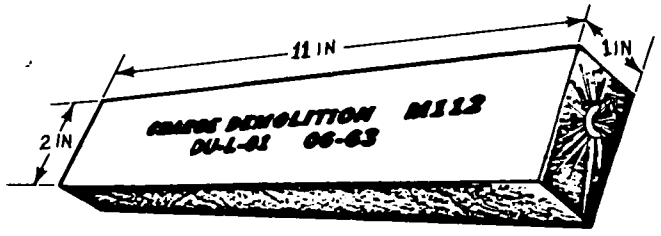



*Figure 1–5. M112 block demolition charge.*

## 1–31. Charge, Demolition: Block, M118 (2-Pound, PETN)

*a. Characteristics.* The M118 block demolition charge or sheet explosive (fig 1–6) is a block of four ½-pound sheets of a flexible explosive packed in a plastic envelope. Twenty M118 charges and a package of 80 M8 blasting cap holders are, in turn, packed in a wooden box. Each sheet of expolsive has a pressure-sensitive adhesive tape attached to one surface. Additional characteristics are listed in table 1–2.

*Note.* Exact explosive contained in M118 demolition charges will vary with manufacturer. At present, some manufacturers use PETN as basic explosive while other manufacturers use RDX. Charges of future manufacture may include still other explosives.

*b. Uses.* The M118 demolition charges are designed for use as a cutting charge, and especially for use against steel targets. The sheets of explosive may be quickly applied to irregular and curved surfaces, and are easily cut to any desired dimensions. The M118 demolition charge may be used for small breaching charges but should not be used as a bulk explosive charge because of its high cost.

*c. Advantages.* The flexibility and adhesive backing of the sheets allow them to be rapidly applied to a large variety of targets. The ½-pound sheets may be cut to desired dimensions, and may be applied in layers to achieve desired thickness. It is not affected by water and may be used in underwater demolitions.

*d. Limitations.* Adhesive tape will not adhere to wet surfaces or frozen surfaces.

***Caution.* Cut sheet explosive with sharp, steel knife on nonsparking surface. Do not use shears.**

*Figure 1–6. M118 block demolition charge.*

## 1–32. Charge, Demolition: Roll, M186

*a. Characteristics.* The M186 roll demolition charge (fig 1–7) is identical to the M118 demolition charge except that the sheet explosive is in the form of a 50-foot roll on a plastic spool, rather than in sheet form. Each foot of the roll provides approximately ½ pound of explosive. Included with each roll are 15 M8 blasting cap holders and a canvas bag with carrying strap. Additional characteristics are given in table 1–2.

*Note.* Exact explosive contained in M186 demolition charges will vary with manufacturer. At present, some manufacturers use PETN as basic explosive while other manufacturers use RDX. Charges of future manufacture may include still other explosives.

*b. Uses.* The M186 roll demolition charge is used in the same manner as the M118 block demolition charge (para 1–31). The M186 charge is especially adaptable for demolishing targets which require the use of flexible explosive in lengths longer than 12 inches.

*c. Advantages.* The M186 roll demolition charge has all the advantages of the M118 charge. The M186 charge may be cut to exact lengths desired.

*d. Limitations.* The adhesive backing will not adhere to wet or frozen surfaces.

***Caution.* Cut sheet explosive with sharp, steel knife on nonsparking surface. Do not use shears.**

## 1–33. Charge, Demolition: Block Ammonium Nitrate, 40-Pound (Cratering)

*a. Characteristics.* The 40-pound ammonium nitrate block demolition charge or cratering

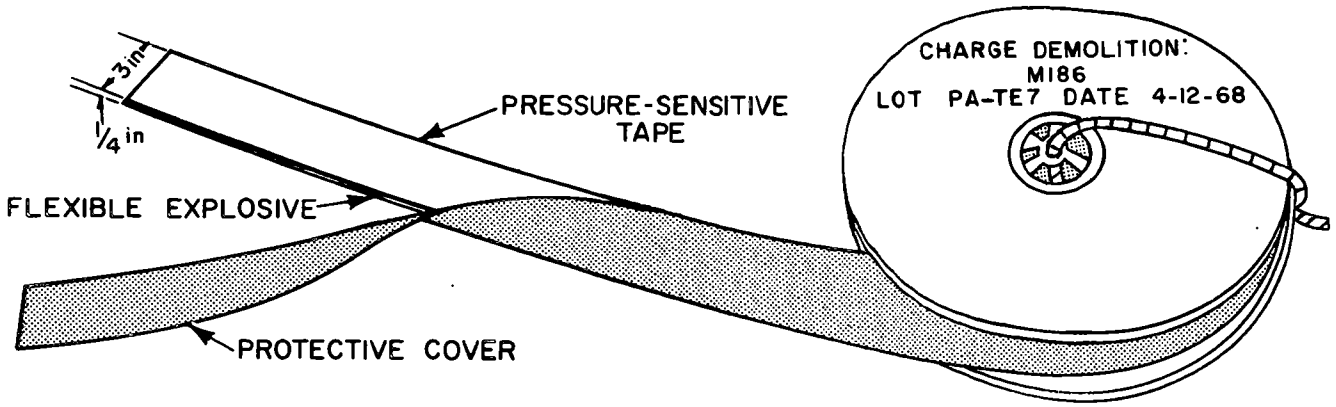



*Figure 1-7. M186 roll demolition charge.*

charge (fig 1-8) is a watertight cylindrical metal container with approximately 30 pounds of an ammonium nitrate based explosive and a TNT based explosive booster of approximately 10 pound in the center portion next to the priming tunnels. The two priming tunnels are attached to the outside of the container midway between the ends. One tunnel serves as a capwell for priming the block demolition charge with an M6 electric or M7 nonelectric military blasting cap. The other tunnel is for priming with detonating cord passed through the tunnel and knotted at the end. A cleat between the tunnels is provided for securing time blasting fuse, electrical firing wire or detonating cord in place. A metal ring is provided on the top of the container for lowering the charge into the hole. Additional characteristics are listed in table 1-2.

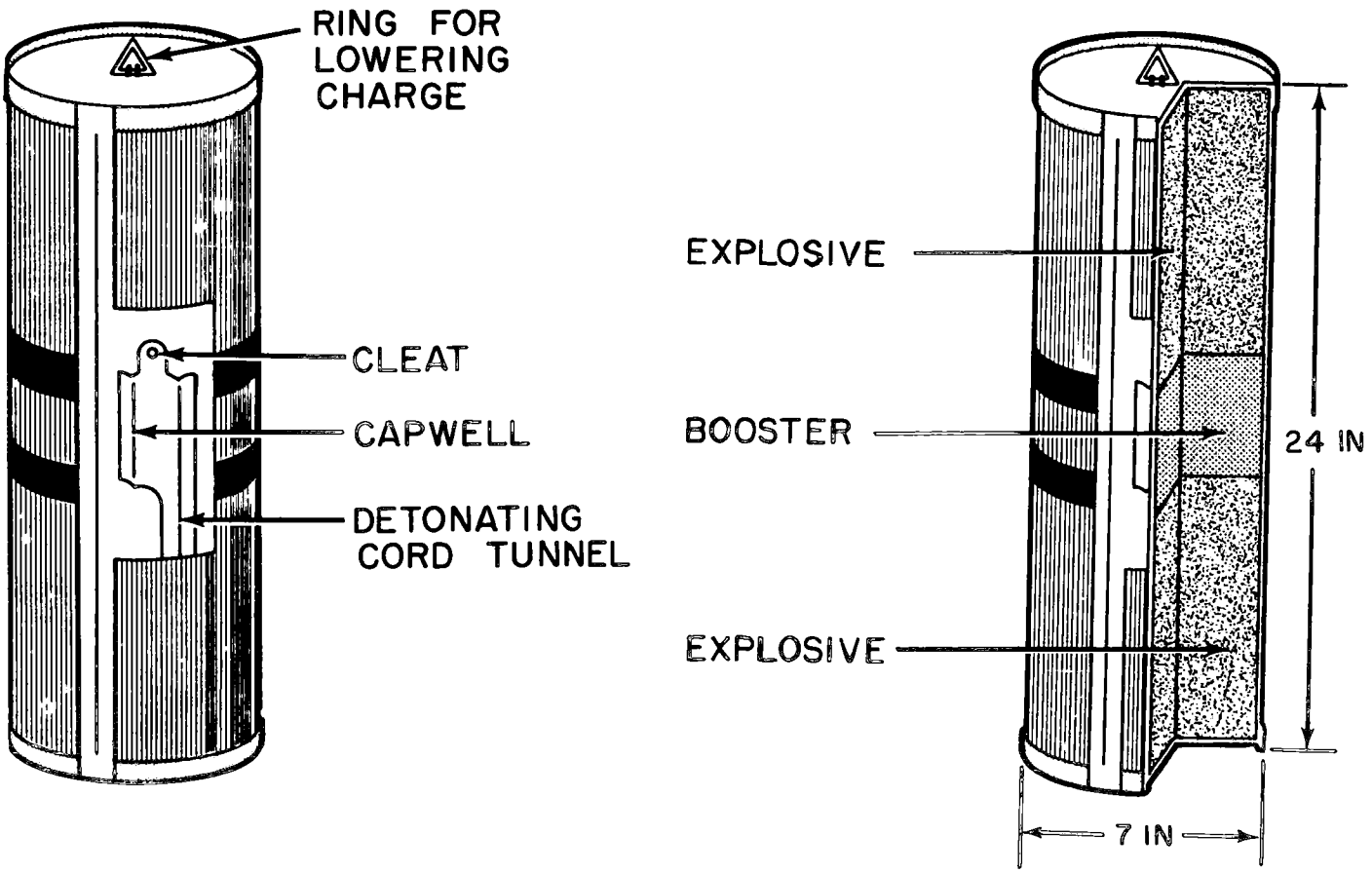



*Figure 1-8. 40-pound ammonium nitrate block demolition charge (cratering charge).*

*b. Uses.* The ammonium nitrate based explosive has a relatively low detonating velocity and is therefore unsuitable for cutting and breaching operations. However, the blast effect, which is related to the pressure of the gases produced, gives it a pushing or heaving effect which makes it suited for cratering and ditching operations. The 40 pound ammonium nitrate block demolition charge has been designed as a standard cratering charge. Because of the large amount of explosive in convenient form, it may also be used in destroying buildings and fortifications and overturning bridge abutments.

*c. Advantages.* The size and shape of the charge make it ideal for cratering operations. It is very inexpensive to produce compared to other explosives.

*d. Limitations.* Ammonium nitrate readily absorbs moisture thereby becoming more difficult to initiate and less effective. It is not possible to detonate wet ammonium nitrate. To insure detonation, the metal containers must be inspected for any evidence of water damage, and all charges placed in wet or damp boreholds should be detonated as soon as possible. Ammonium nitrate cratering charges should be dual primed.

## Section IV. DYNAMITES

### 1–34. Dynamite: Military, M1

*a. Characteristics.* M1 military dynamite (fig 1–9) is an RDX based composite explosive and contains no nitroglycerine (para 1–23), and thus is safer to store, handle, and transport than commercial dynamite. M1 military dynamite is packaged in ½-pound paraffin-coated cylindrical paper cartridges, which have a nominal diameter of 1¼ inches and nominal length of 8 inches. Additional characteristics are given in table 1–3.

*b. Uses.* M1 military dynamite is for general use as medium velocity blasting explosive to replace 60-percent commercial dynamites in military construction, quarrying, ditching, and service demolition work. It is suitable for underwater demolitions.

*c. Advantages.* Military dynamite will not freeze in cold storage, nor exude in hot storage. The composition does not absorb or retain moisture. Shipping containers do not require turning in storage. Safety in transportation, storage, and handling is better than that of 60-percent commercial dynamite. It may be used in combat areas.

*d. Limitations.* It is reliable underwater only up to 24 hours. Because of its low sensitivity, sticks of military dynamite must be well com-

*Table 1–3. Characteristics of Dynamites*

| Name | | Principal uses | Velocity of detonation (meters/sec) (feet/sec) | Relative effectiveness as a breaching charge | Intensity of poisonous fumes | Water resistance |
|---|---|---|---|---|---|---|
| Military dynamite, M1 | | Demolition charge | 6,100 mps, 20,000 fps | 0.92 | Dangerous | Good. |
| Straight dynamite (commercial) | 40% | Demolition charges | 4,600 mps, 15,000 fps | 0.65 | Dangerous | Good (if fired within 24 hours). |
| | 50% | | 5,500 mps, 18,000 fps | 0.79 | | |
| | 60% | | 5,800 mps, 19,000 fps | 0.83 | | |
| Ammonia dynamite (commercial) | 40% | | 2,700 mps, 8,900 fps | 0.41 | Dangerous | Poor. |
| | 50% | | 3,400 mps, 11,000 fps | 0.46 | | |
| | 60% | | 3,700 mps, 12,000 fps | 0.53 | | |
| Gelatin dynamite (commercial) | 40% | | 2,400 mps, 7,900 fps | 0.42 | Slight | Good. |
| | 50% | | 2,700 mps, 8,900 fps | 0.47 | | |
| | 60% | | 4,900 mps, 16,000 fps | 0.76 | | |
| Ammonia gelatin dynamite (commercial) | 40% | | 4,900 mps, 16,000 fps | ---- | Slight | Excellent. |
| | 60% | | 5,700 mps, 18,700 fps | ---- | | |

pacted to assure complete detonation of the entire charge, e.g., there must be no voids in loading of boreholes in quarrying. This characteristic combined with the fact that military dynamite will eventually detonate if set afire in a confined space can result in a secondary explosion from a borehole with a void in its loading. It may take up to 15 minutes for such an explosion to occur after the first blast. Because of its medium velocity and cylindrical shape, it is not efficient as a cutting or breaching charge.

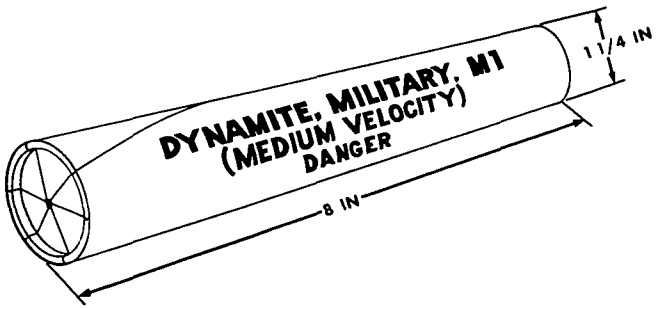



*Figure 1-9. Military dynamite, M1.*

## 1-35. Commercial Dynamites

*a. Types.* Commercial dynamite (fig 1-10) is somewhat sensitive to shock and friction. Therefore, it is not generally used in forward areas, but it is acceptable in emergencies when other more suitable explosives are not available. Commercial types of dynamite are straight, ammonia, gelatin, and ammonia-gelatin. Characteristics are given in table 1-3.

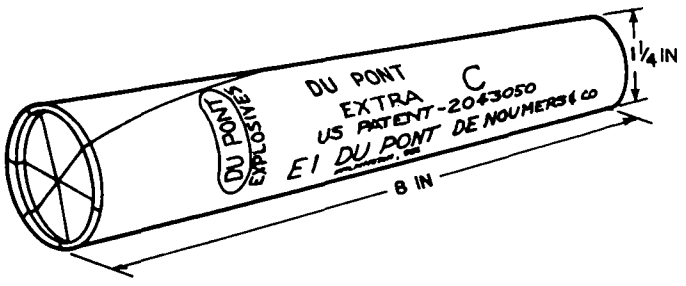



*Figure 1-10. Commercial dynamite.*

(1) Straight dynamite consists of nitroglycerine and a nonexplosive filler. The percentage corresponds to the relative amount of nitroglycerine contained in each stick.

(2) Ammonia dynamite is composed of ammonium nitrate and nitroglycerine. Its percentage composition is computed in a manner similar to that for straight dynamite.

(3) Gelatin dynamite is a plastic dynamite with an explosive base of nitrocotton dissolved in nitroglycerine and is relatively insoluble in water. It is applicable to underwater demolitions, land clearing, cratering, and quarrying of hard rock.

(4) Ammonia-gelatin dynamite is a plastic dynamite with an explosive base of nitrocotton dissolved in nitroglycerine with ammonium nitrate added. It is suitable for underwater use.

*b. Detonation.* Commercial dynamites may be exploded when primed with a commercial No. 6 or larger blasting cap, a military electric or nonelectric blasting cap, or detonating cord.

*c. Storage.* When straight dynamite is stored, the nitroglycerine tends to settle through the bottom of the sticks; accordingly, straight dynamite cases should be turned at frequent, regular intervals to help prevent this. (See TM 9-1300-206.)

*d. Old Dynamite.* Old dynamite may be recognized by the oily substance collected on the casing or by stains appearing on the wooden packing case. These stains are caused by the separation of the nitroglycerine from the porous base. Dynamite in this state is extremely sensitive and must not be used. It should be destroyed in accordance with TM 9-1300-206 or the manufacturer's recommendations.

*e. Low Temperature Effects.* The sensitivity of commercial dynamite decreases at lower temperatures until the dynamite freezes. Because of the crystallization which occurs as nitroglycerine freezes, dynamite becomes extremely sensitive and should not be used. Frozen dynamite is recognized by its hardness and by the appearance of crystals.

# Section V. SPECIAL DEMOLITION CHARGES AND ASSEMBLIES

## 1-36. Shaped Demolition Charges

Shaped demolition charges (fig 1-11) used in military operations are cylindrical blocks of high explosive having a conical or hemispherical cavity in one end which directs the cone liner material into a narrow jet for penetrating metal, concrete, earth or other materials. It is not effective for underwater use since water in the con-

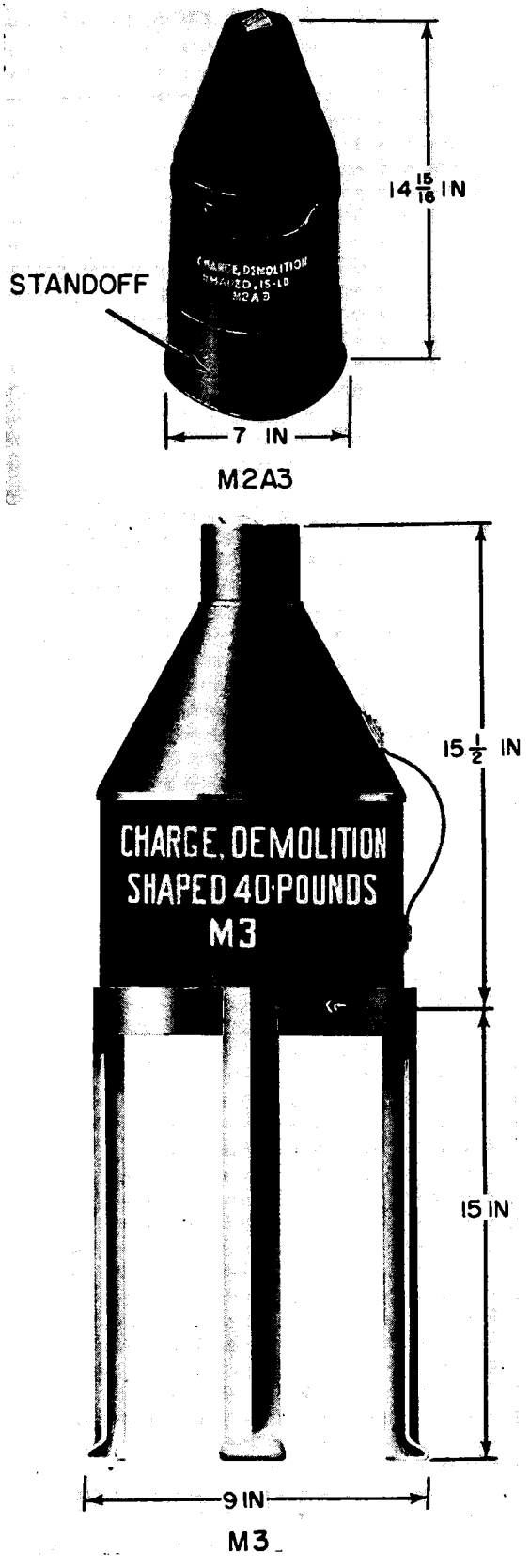



*Figure 1–11. Typical shaped charges.*

ical cavity will prevent the high velocity jet from forming. To obtain maximum effectiveness the cavity must be located at a certain stand-off distance from the target and the charge must be detonated from the exact rear center of the charge. Thus, conventional methods of dual priming are not applicable to shaped charges.

*a. Charge, Demolition: Shaped, 15-Pound, M2-A3.* This charge contains approximately 9½ pounds of composition B with a 50–50 pentolite booster weighing approximately 2 pounds in a moisture-resisting molded fiber container. Older models are completely pentolite loaded. A cylindrical fiber base slips on the end of the charge to provide a stand-off distance. A cone of glass is used as a cavity liner in this charge. Additional characteristics are listed in table 1–3.

*b. Charge, Demolition: Shaped, 15-Pound, M2-A4.* Charge M2A4 was developed to provide a charge less sensitive to gunfire than charge M2-A3. Charge M2A4 is identical to charge M2A3 in performance, but differs in the booster size and materials as follows: The 50–50 pentolite booster has been replaced by 50 grams of composition A3. Also, the main charge of composition B has been increased to maintain the same total weight as charge M2A3. Characteristics are listed in table 1–4.

*c. Charge, Demolition: Shaped, 40-Pound, M3.* This shaped charge contains approximately 27½ pounds of composition B with a 50–50 pentolite booster, in a metal container. The cavity liner is made of metal. A metal tripod for obtaining a stand-off distance is also provided. Characteristics of this charge are listed in table 1–4.

*d. Charge, Demolition: Shaped, 40-Pound, M3-A1.* Charge M3A1 was developed to provide a charge less sensitive to gunfire than charge M3. Charge M3A1 is identical to charge M3 in performance, but differs in the booster size and material as follows: The 50–50 pentolite booster has been replaced by a booster of approximately 50 grams of composition A3. Also the main charge of composition B has been increased to maintain the same total weight as charge M3.

*e. Uses.* Shaped demolition charges are used primarily to bore holes in earth, metal, masonry, concrete, and paved and unpaved roads. Their effectiveness depends largely on their shape and the material of which they are made, the explosive, and proper placement. The penetrating capabilities in various materials and proper stand-off distances are given in table 3–5.

*f. Special Precautions.* In order to achieve the maximum effectiveness of shaped charges—

(1) Center the charge over the target point.

(2) Set the axis of the charge in line with the direction of the desired hole.

(3) Use the pedestal provided to obtain the proper stand-off distance.

(4) Be certain that there is no obstruction in the cavity liner or between the charge and the target.

## 1–37. M183 Demolition Charge Assembly

The M183 demolition charge assembly (fig 1–12) or "satchel charge" is used primarily in breaching obstacles or demolition of large structures where large demolition charges are used. It is

*Table 1–4. Characteristics of Shaped Demolition Charges*

| Type | Explosive | Weight | Size | Packaging |
|---|---|---|---|---|
| CHARGE, DEMOLITION: shaped 15-lb, M2A3. | Pentolite or composition B, with 50/50 pentolite booster. | 15 lb | 14 15/16 x 7 in. w/ fiberboard standoff. | 1. 2 per wooden box, 58 lbs. 2. 3 per wooden box, 65 lbs. |
| CHARGE, DEMOLITION: shaped 15-lb, M2A4. | Composition B, with composition A3 booster. | 15 lb | 14 15/16 x 7 in. w/ fiberboard standoff. | 3 per wooden box, 65 lbs. |
| CHARGE, DEMOLITION: shaped 40-lb, M3. | Composition B, with 50/50 pentolite booster. | 40 lb | 15½ x 9 in. less standoff. | 1 charge per wooden box, 65 lbs. |
| CHARGE, DEMOLITION: shaped 40-lb, M3A1. | Composition B, with composition A3 booster. | 40 lb | 15½ x 9 in. less standoff. | 1 charge per wooden box, 65 lbs. |

also effective against obstacles such as small dragon's teeth approximately 3 feet high and 3 feet wide at the base. The M183 demolition charge assembly replaces the M37 demolition charge assembly (para 1–38) as the standard item of issue.

*a. Components.* The M183 demolition charge assembly consists of sixteen M112 (Comp. C–4) demolition blocks, and four priming assemblies for a total explosive weight of 20 pounds. The demolition blocks are packed in two bags, eight blocks per bag, and placed in an M85 canvas carrying case. Each priming assembly consists of a 5-foot length of detonating cord with an RDX booster crimped to each end and a pair of M1 detonating cord clips for attaching the priming assembly to a detonating cord main line.

*b. Detonation.* The M183 demolition charge assembly is detonated by means of the priming assembly and an electric or nonelectric blasting cap or by a detonating cord ring main attached by means of the detonating cord clips provided.

*c. Packaging.* One assembly is packed in a canvas carrying bag, and two bags are packed in a wooden box 17⅛ x 11½ x 12½ inches. The gross package weight is 57 pounds.

## 1–38. M37 Demolition Charge Assembly

The M37 demolition charge assembly (fig 1–13) consists of four M5A1 (Comp. C–4) demolition blocks per bag; two bags and two M15 priming assemblies per canvas carrying bag for a total explosive weight of 20 pounds. Two demolition charge assemblies are packed in a wooden box (total weight: 57 pounds). The M37 demolition charge assembly has been replaced by the M183 demolition charge assembly (para 1–37). The M37 assembly is detonated and used in the same manner as the M183 assembly and may be used as a substitute for it. Each M15 priming assembly has two M4A1 priming adapters to facilitate attachment of the boosters into the M5A1 demolition blocks.

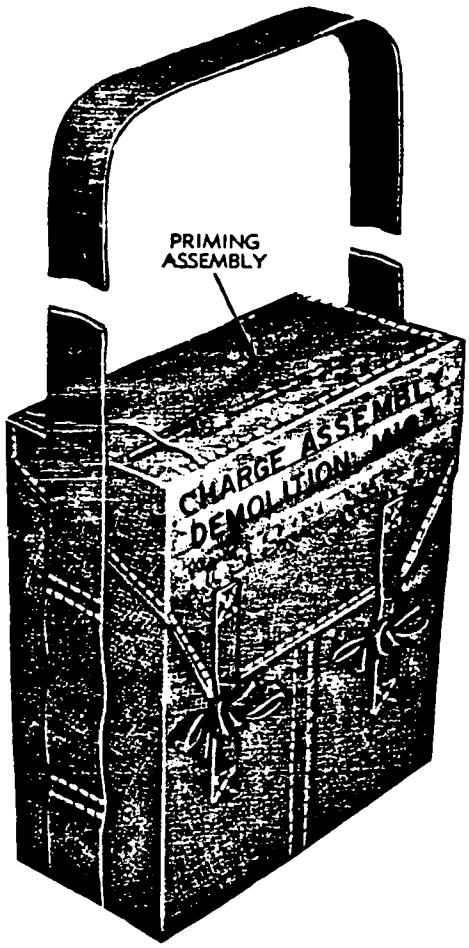



*Figure 1–12. M183 demolition charge assembly.*

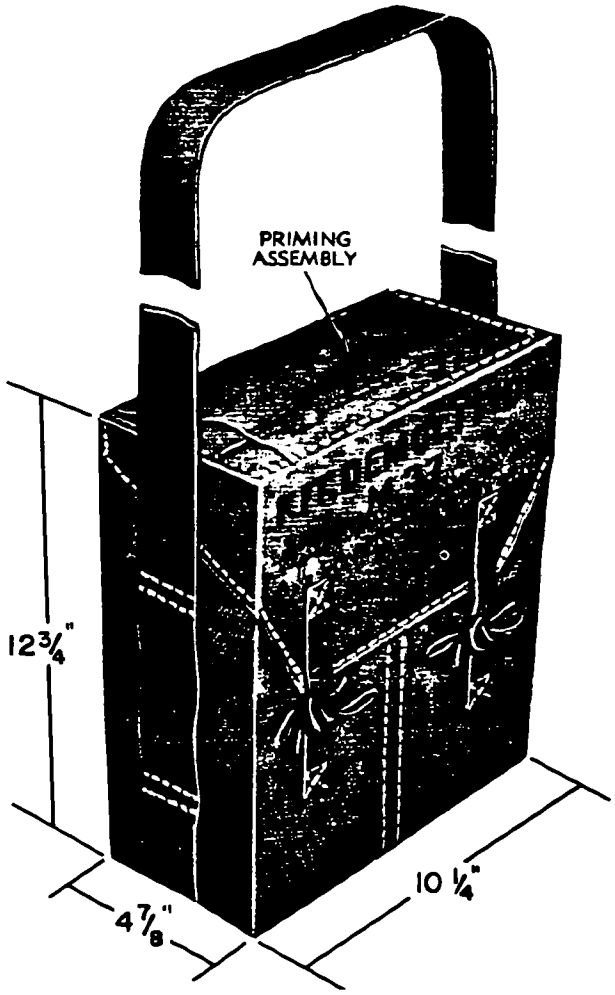



*Figure 1–13. M37 demolition charge assembly.*

## 1–39. Demolition Kits, Bangalore Torpedo, M1A1 and M1A2

*a. Characteristics.* These kits consist of a group of 10 loading assemblies or torpedoes. The loading assemblies or torpedoes are steel tubes 5 feet in length and 2⅛ inches in diameter, grooved, and capped at each end (fig 1–14). The torpedoes in the M1A1 kit are loaded with amatol, with a 4-inch booster of TNT at each end. The torpedoes in the M1A2 kit are identical to the M1A1 kit except the main explosive charge is composition B and the booster at each end is composition A3. All torpedoes have a threaded capwell at each end. Connecting sleeves and nose sleeves are provided in each kit. Additional characteristics are listed in table 1–5.

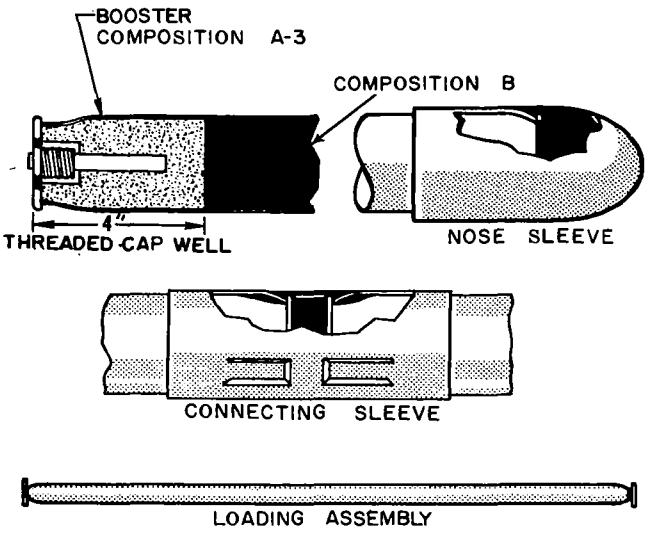



*Figure 1–14. M1A2 bangalore torpedo.*

*b. Uses.* The bangalore torpedo demolition kit is used to clear paths through barbed wire entanglements and minefields. It clears a path 3 to 4 meters wide through barbed wire entanglements. In minefield breaching, it will explode all antipersonnel mines and most of the antitank mines in a narrow foot path. Many of the mines at the sides however may be shocked into a sensitive state, which makes extreme care necessary in any further mineclearing. Bangalore torpedoes have also been used successfully for clearing heavy undergrowth or bamboo.

*c. Assembly.* All sections have a threaded cap well at each end so that they may be assembled in any order. The connecting sleeves make rigid joints. A nose sleeve is placed on the front of the torpedo to assist in pushing it through entanglements and across the ground. It is also desirable to attach an improvised part similar to a loading section without explosive on the end to forestall premature detonation by a mine when the torpedo is shoved into place. In the assembly of two or more tubes, the nose sleeve is pressed onto one end of one tube, and the other end is connected to a second tube by a connecting sleeve.

*d. Detonation.* The military electric or nonelectric blasting caps will detonate the bangalore torpedo. In obstacle clearance, the bangalore torpedo should be primed after it has been placed. The cap well at the end should be protected with tape or a wooden plug while the torpedo is being pushed into place. Priming is done either by means of priming adapter and a military electric or nonelectric blasting cap and time fuse or by use of 8- or 15-second delay detonators.

## 1–40. Projected Charge Demolition Kits

*a. General.* Projected charge demolition kits consist of semirigid or flexible linear demolition charges together with other components required to transport the charge, to project or pull the charge into position, and to detonate it. They are designed to clear a pathway through antipersonnel or antitank minefields. Some kits may also be used against other types of obstacles.

*b. M1 and M1A1 (M1E1) Projected Charge Demolition Kits (Antipersonnel Mine-Clearing).* These kits are identical in all respects except for the delay detonators and the time blasting fuse

*Table 1–5. Characteristics of Bangalore Torpedoes*

| Type | Components | Torpedo weight | Explosive per torpedo | Packaging |
|---|---|---|---|---|
| M1A1 | 10 loading assemblies or torpedoes; 10 connecting sleeves; one nose sleeve. | Approx. 13 lbs. | Approx 9 lbs amatol and TNT booster. | One kit packed in wooden box, 64⅛ x 13⅞ x 7⅛ in. Total weight 176 lbs. |
| M1A2 | 10 loading assemblies or torpedoes; 10 connecting sleeves; one nose sleeve. | Approx. 15 lbs. | Approx 10.5 lbs comp. B4 and 1 lb. comp. A3 booster. | One kit packed in wooden box, 60⅜ x 13¾ x 4 9/16 in. Total weight 198 lbs. |

igniters issued with them. The M1A1 (M1E1) has the M60 weatherproof time blasting fuse igniter and the 15-second delay M1A2 percussion detonator, while the M1 has the M2 weatherproof time blasting fuse igniter and the 15-second delay M1 or M1A1 friction detonator (fig 1–15). For a complete description of these kits see TM 9–1375–200.

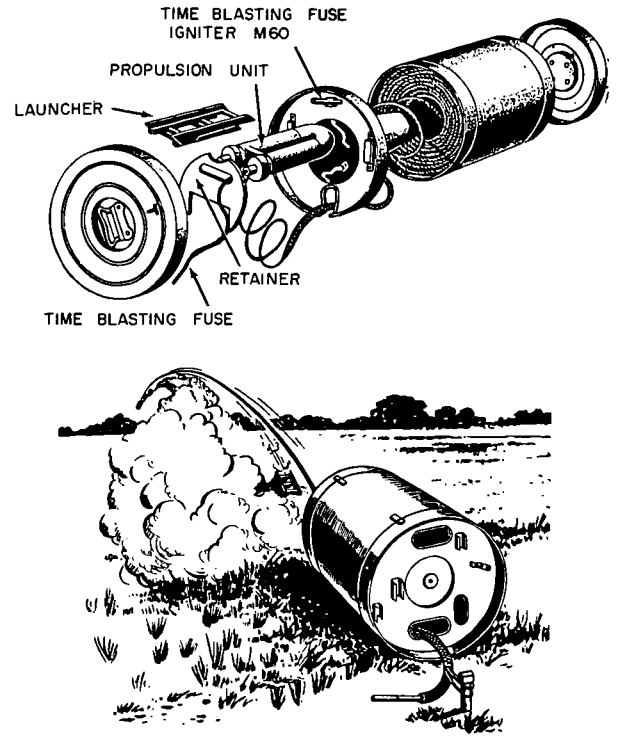



*Figure 1–15. M1A1 projected charge kit.*

(1) *Components.* These kits consist of a nylon-covered detonating cable, propulsion unit, launcher, fuse igniter, delay detonator, anchor stake, and carrying case. The explosive item, or detonating cable, is 1 inch in diameter and approximately 170 feet (52 meters) long; it weighs 63 pounds, 46 pounds of which is oilsoaked PETN. The detonating cable is composed of 19 strands of special detonating cord, each containing 100 grains of PETN per foot. This differs from the regular (reinforced) detonating cord, which contains only 50 to 60 grains of PETN per foot. Regular detonating cord cannot be used as a substitute in the kit.

(2) *Use.* This kit is emplaced to project and detonate a cable across a pressure-actuated antipersonnel minefield. Grass, leaves, other light vegetation, and some soil are blown aside in a lane about 8 feet wide. More soil is blasted aside when the ground is moist and soft than when it is dry and hard. Camouflaged antipersonnel mines and those near the surface in the 8 foot lane are usually exposed. These kits are not effective against other types of obstacles.

(3) *Detonation.* Two men are required to emplace and fire the kit. After emplacing the kit and choosing an area about 100 feet behind the kit offering cover to men in a prone position, one man takes cover; the igniter for the rocket is functioned by the other man. In older kits this man then moves to and functions the delay detonator for the detonating cable and then takes cover. In newer kits, the man takes cover immediately after functioning the igniter, and the delay detonator is then functioned from cover by means of a lanyard after the rocket fires.

(4) *Packaging.* The complete assembly is issued in an OD-colored waterproof aluminum carrying case. Each case is sealed in a barrier bag and packed in a wooden box 25½ x 18⅜ x 19¼ inches. The gross weight of the kit and box is 142 pounds.

*c. M–157 Projected Charge Demolition Kit (Antitank Mine-Clearing).* This demolition kit (fig 1–16) is an antitank mine-clearing device designed to be towed and pushed for emplacement by a medium tank with accessories. For a complete physical description, assembly procedure, operational description, and maintenance instruction of this kit, refer to TM 9–1375–204–10 and TM 9–1375–200.

(1) *Description.* This kit (fig 1–16) measures about 12 inches in width, 7 inches in height, and 400 feet (121.9 meters) in length. It consists of 79 sections—1 nose section, 13 body sections, 62 center-loading sections, 2 impact fuze sections, and 1 tail section. Only 64 of the 79 sections contain explosives—the 62 center loading sections and the 2 impact fuze sections. The kit weight 11,000 pounds including approximately 3,200 pounds of explosive. The explosive is a linear shaped charge, 12 inches wide, 7 inches high, and 5 feet long, containing approximately 45 pounds of composition B and 5 pounds of composition C4. As the insert tubes are welded to the walls of the center loading sections, the explosive elements cannot be used as separate charges or replaced by any substitute item in the field. The linear shaped charge insures a wider, clearer path throughout minefields than many other explosive clearing devices.

(2) *Uses.* This kit is designed to clear a path large enough for tanks, vehicles, and personnel to travel through minefields planted with single-

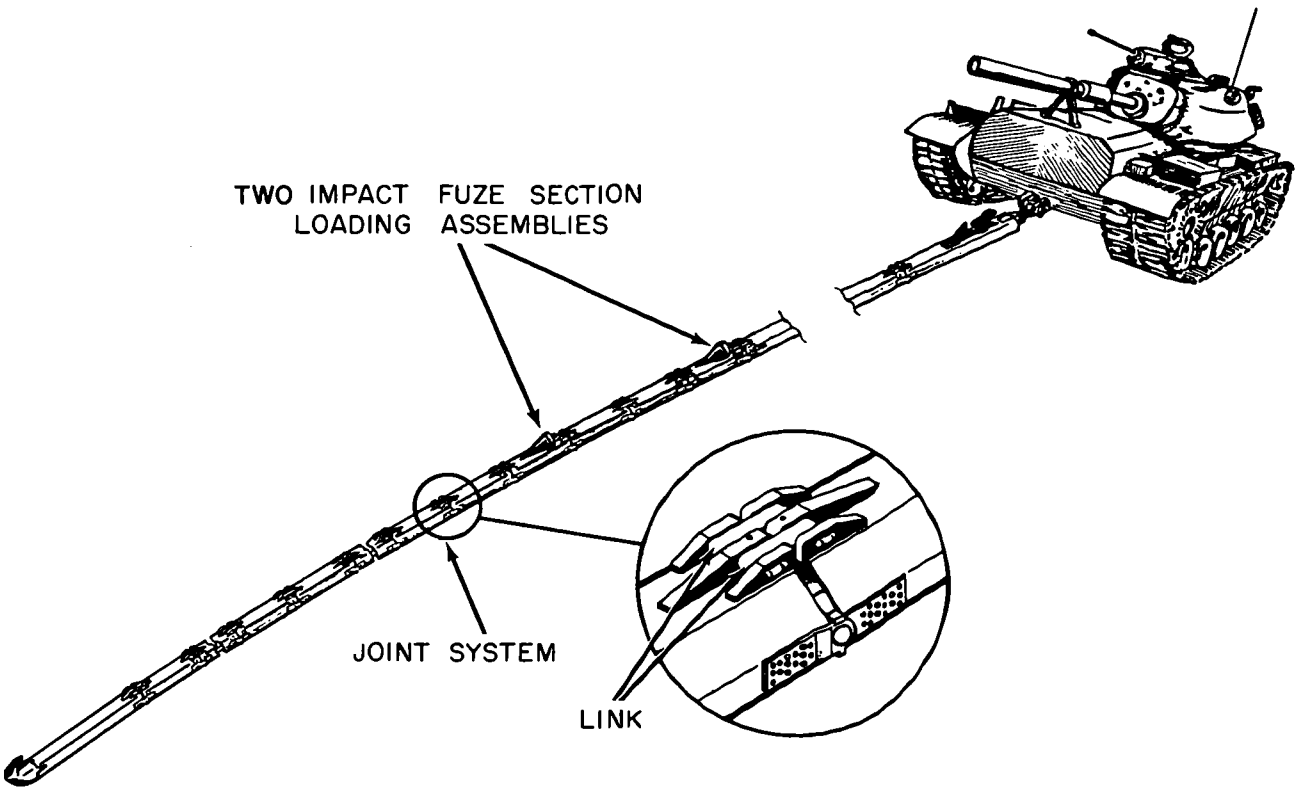



*Figure 1–16. M–157 projected charge demolition kit.*

impulse, pressure-type antitank mines. In most soils this charge forms a crater about 100 meters long, 4 to 5 meters wide, and 1 to 1½ meters deep. This kit is also effective against bands of log posts, steel rail posts, antitank ditches, and small concrete obstacles. This charge will break down the sides of an antitank ditch and clear a path through the ditch adequate for tank traffic if it is unrevetted and 5 feet deep or less and if the charges project beyond the far side of the ditch.

(3) *Detonation.* The charge is detonated from a tank by means of bullet impact fuze, which has a target plate that bears on the firing pin and is held in place by a shear pin and a safety fork that must be removed before the fuze can be actuated. The fuze is detonated by fire from the tank's machine guns. Two fuzes are provided to insure that one is visible to the tank gunner at all times.

*d. M–173 Projected Charge Demolition Kit (Antitank Mine-Clearing).*

(1) *Description.* This kit (fig 1–17) consists of a waterproof skid M3, a linear charge propulsion system, a linear demolition charge, and necessary accessories to tow and fire the kit. The kit measures 24-inches high, 56.5-inches wide, and 145-inches long, and weighs approximately 3,100 pounds. The linear demolition charge M96 is 300 feet in length and contains 1,500 pounds of composition C4 explosive. For a complete description assembly procedures, and operational and maintenance instructions refer to TM 9–1375–202–10.

(2) *Use.* The M173 projected charge demolition kit is an antitank minefield clearing device designed to be towed by a vehicle to the edge of a minefield. The kit is positioned at the edge of the minefield and a rocket projects the linear demolition charge across the minefield. The charge is then detonated to clear a path in minefields planted with single-impulse, pressure-type mines.

(3) *Detonation.* The firing of the kit is accomplished electrically from any vehicle containing a suitable 24-volt direct current bayonet-type outlet.

## 1–41. Explosive Kit, Earth Rod, Set No. 1

The earth rod kit (fig 1–18) is a special explosive kit used for making holes for demolitions or construction purposes. It will bore holes up to 6 feet deep and several inches in diameter in earth or soft shale. It is not usable in frozen

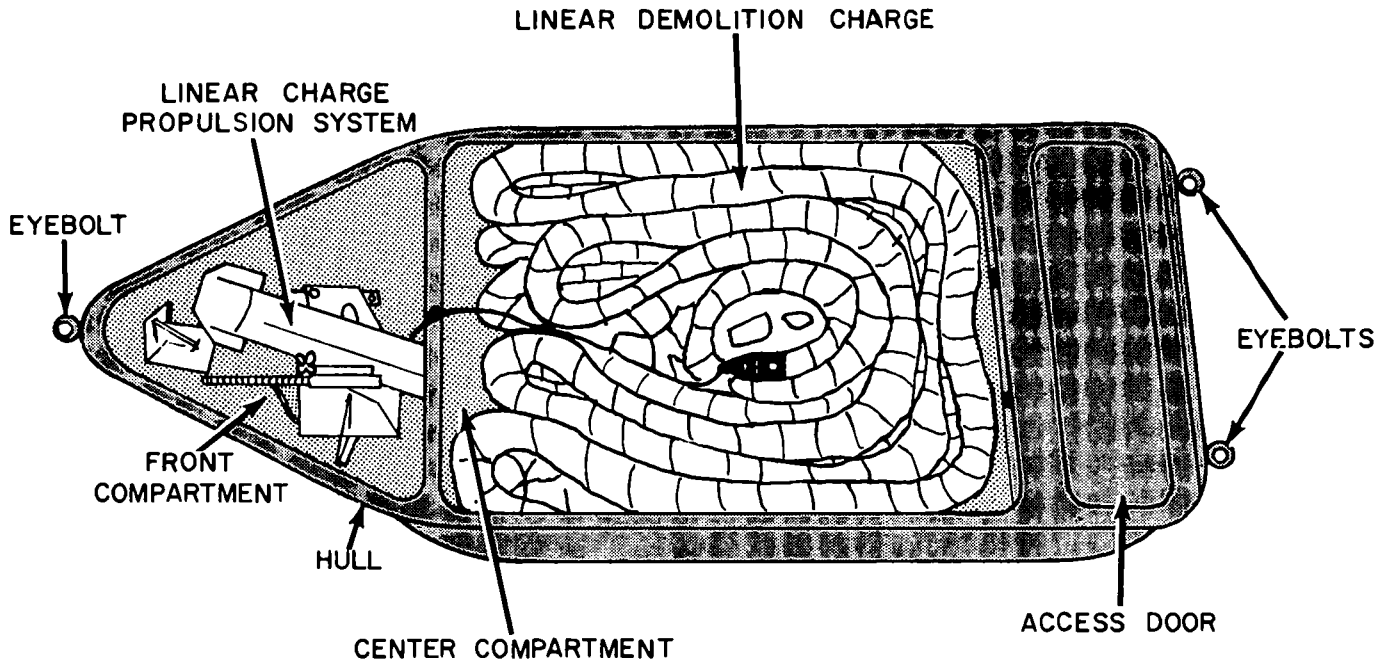



*Figure 1–17. Projected charge demolition kit M–173—main cover removed.*

ground, in rock or other hard material. A 6-foot long steel rod with point and firing chamber is driven into the earth by the propelling charge, which is exploded in the firing chamber. A removable handle (extractor rod), which fits through holes in the firing chamber, and an extension are used for gripping and lifting the rod from the earth. A linear demolition charge is furnished for enlarging the diameter of the hole. A forked insertion rod is also furnished for insertion of improvised linear charges (made up of a bundle of detonating cords) when the standard ones are not available. (See TM 9–1375–200.) The following is a list of components in the earth rod kit.

*Note.* The item letters correspond to the small letters in figure 1–18.

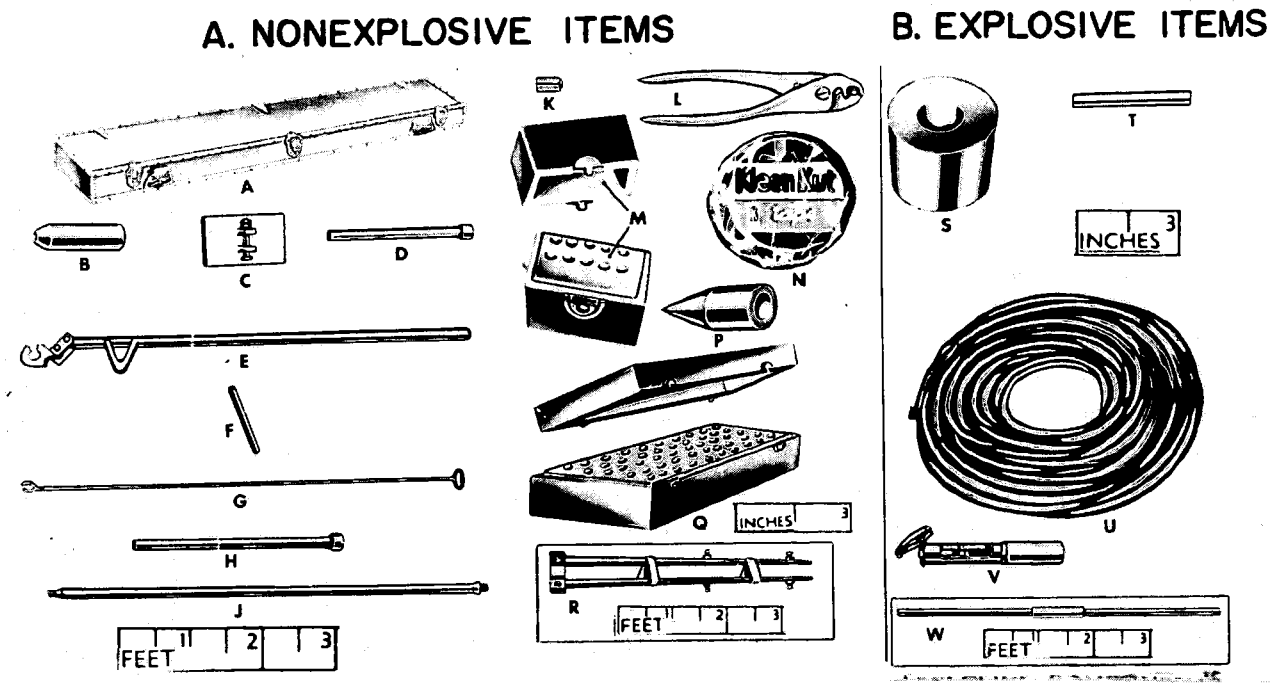



*Figure 1–18. Earth rod kit.*

*a. Nonexplosive Items.*

| Item letter | Quantity | Item |
|---|---|---|
| A | 1 | Chest |
| B | 1 | Chamber, firing |
| C | 1 | Plate, base, extractor, assembly |
| D | 1 | Rod, extension |
| E | 1 | Extractor, rod |
| F | 1 | Rod, handle and starting |
| G | 1 | Rod, inserting |
| H | 2 | Rod, intermediate |
| J | 2 | Rod, main, long |
| K | 100 | Adapter, priming, explosive, M1A4 |
| L | 1 | Crimper, cap, M2 (w/fuse cutter) |
| M | 1 | Box, cap, 10-cap capacity, infantry |
| N | 2 | Insulation tape, electrical, black adhesive cotton, ¾-inch wide |
| P | 100 | Point |
| Q | 2 | Box, cap, 50-cap capacity, engineer |
| R | 1 | Tripod |

*b. Explosive Items.*

| Item letter | Quantity | Item |
|---|---|---|
| S | 100 | Charge, propelling, earth rod, M12 (w/primer, M44) |
| T | 100 | Cap, blasting, special, non-electric, M7 |
| U | 2 | Fuse, blasting, time 50-ft coil |
| V | 200 | Igniter, time blasting fuze, M2, weatherproof |
| W | 100 | Charge, demolition, linear (two 3-ft sections and one connecting sleeve) |

## Section VI. DEMOLITION ACCESSORIES

### 1–42. Time Blasting Fuse

Time blasting fuse transmits a flame from a match or igniter to a nonelectric blasting cap or other explosive charge, providing a time delay wherein blasters may retire to a safe distance prior to the explosion. There are two types: safety fuse and time fuse M700. These may be used interchangeably.

*a. Safety Fuse.* Safety fuse is used in general demolitions. It consists of black powder tightly wrapped with several layers of fiber and waterproofing material and may be any color, orange being the most common (fig 1–19). The burning rate may vary for the same or different rolls from 30 to 45 seconds per foot under different atmospheric and climatic conditions (exposure for over 12 hours to the elements, extreme changes in temperature, and the like), and each roll must be tested prior to using in the area where the charge is to be placed (see para 2–2). Particular precautions must be taken if used under water, as the rate of burning is increased significantly. Accordingly, each roll should be tested under water prior to preparation of the charge. In arctic temperatures, the outside covering becomes brittle and cracks easily.

*b. Time Fuse M700.* This fuse (fig 1–20) is similar to safety fuse and may be used interchangeably with it. The fuse is a dark green cord 0.2 inches in diameter with a plastic cover. Depending on the time of manufacture, the cover may be smooth or have single bands around the outside at 1-foot or 18-inch intervals and double bands at 5-foot or 90-inch intervals. These bands are provided for easy measuring purposes. The burning rate is approximately 40 seconds per foot. The burning rate, however, must always be tested in the same manner as that of safety fuse. At arctic temperatures, the outside covering becomes brittle and cracks easily.

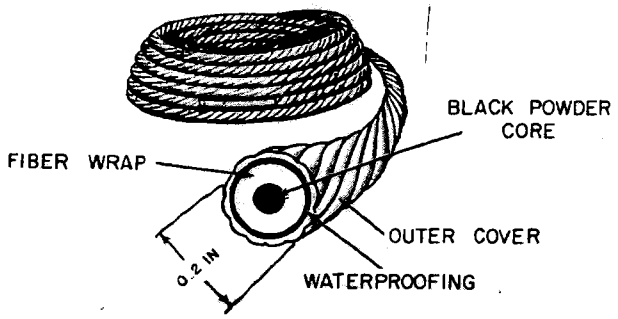



*Figure 1–19. Safety fuse.*

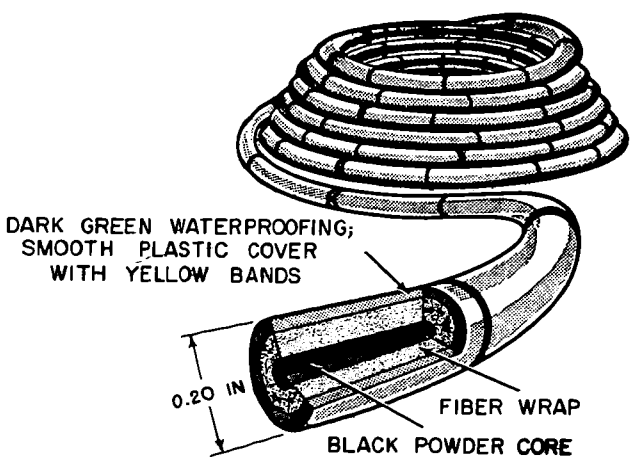



*Figure 1–20. Time fuse M700.*

*c. Packaging.*

(1) *Safety fuse.*

(*a*) 50-foot coil, 2 coils per package, and 30 packages (3,000 feet) in a wooden box 24¾ x 15¾ x 12½ inches. The total package weight is 71.8 pounds.

(*b*) 50-foot coil, 2 coils per package, 5 packages sealed in a metal can, and 8 cans (4,000 feet) per wooden box 30 x 14⅝ x 14⅝ inches. The total package weight is 93.6 pounds.

(*c*) 50-foot coil, 2 coils per package, and 60 packages (6,000 feet) per wooden box 29 x 22 x 17 inches. The total package weight is 162 pounds.

(2) *Time fuse M700.* This is packed in 50-foot coils, 2 coils per package, 5 packages per sealed container, and 8 containers (4,000 feet) per wooden box 30⅛ x 15⅛ x 14⅞ inches. The total package weight is 94 pounds.

## 1–43. Detonating Cord

*a. Characteristics.* Detonating cord consists of a core of PETN or RDX in a textile tube coated with a thin layer of asphalt. On top of this is an outer textile cover finished with a wax gum composition or plastic coating (fig 1–21). It will transmit a detonating wave from one point to another at a rate of between 20,000 and 21,000 feet per second. Partially submerged water-soaked detonating cord will detonate if initiated from a dry end. Although it does not lose its explosive properties by exposure to low temperatures, the covering becomes stiff and cracks when bent. Thus great care is required in using detonating cord primers in arctic conditions. Data on the types available is shown on table 1–6.

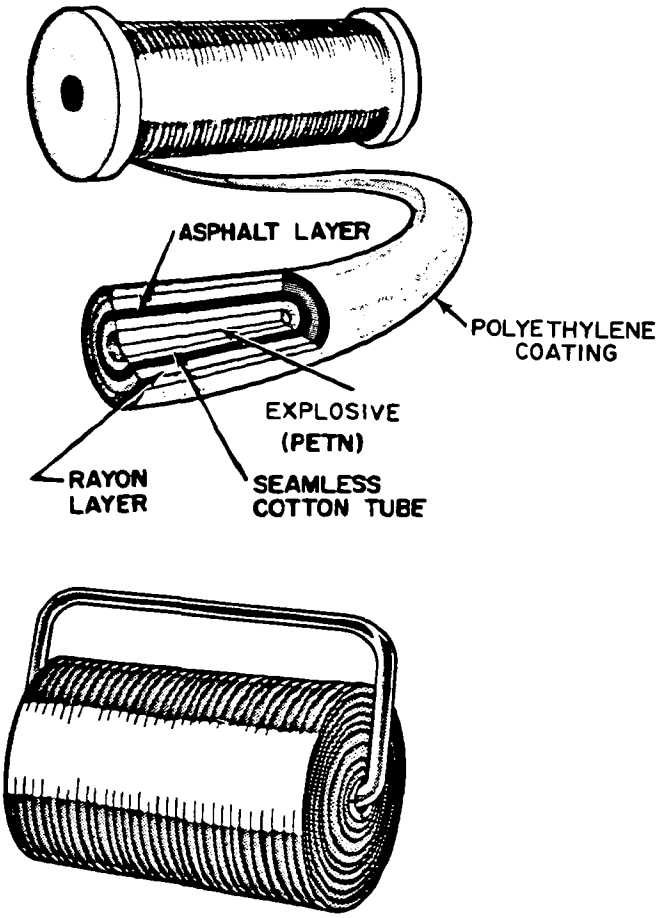



*Figure 1–21. Reinforced pliofilm-wrapped detonating cord.*

*b. Use.* Detonating cord is used to prime and detonate other explosive charges. When its explosive core is detonated by a blasting cap or other explosives device it will transmit the detonation wave to an unlimited number of explosive charges. (See chap. 2)

*Table 1–6. Detonating Cord Data*

| Type | Class | Minimum weight of explosive core per 1,000 ft. | Nominal diameter (inches) | Maximum weight of finished cord per 1,000 ft (lbs) | Minimum breaking strength (pounds) |
|---|---|---|---|---|---|
| I | a | 5 pounds PETN | 0.175 | 14 | 60 |
| I | b | 6 pounds PETN | 0.216 | 19 | 175 |
| *I | c | 6.4 pounds PETN | 0.200 | 18 | 175 |
| I | d | 7 pounds PETN | 0.200 | 19 | 110 |
| I | e | 7 pounds PETN | 0.235 | 22 | 190 |
| I | f | 12.5 pounds PETN | 0.245 | 26 | 75 |
| I | g | 12.5 pounds PETN | 0.270 | 33 | 190 |
| I | h | 14.5 pounds PETN | 0.235 | 29.5 | 110 |
| I | j | 6.4 pounds PETN | 0.200 | 18 | 150 |
| II | a | 7 pounds RDX | 0.216 | 19 | 175 |
| II | b | 8.5 pounds RDX | 0.255 | 22 | 190 |
| III | — | All type III det. cord is inert loaded with a PVC filler. | | | |

*This detonating cord (Type I, class c) has been agreed upon as "standard" within the American-British-Canadian-Australian Standardization Program.

*c. Precautions in Use.* The ends of detonating cord should be sealed with a waterproof sealing compound to keep out moisture when used to detonate underwater charges, or charges left in place several hours before firing. A 6-inch free end will also protect the remainder of a line from moisture for 24 hours. In priming, kinks or short bends, which may sharply change the direction of detonation and thus cause misfires, should be avoided.

## 1–44. Blasting Caps

Blasting caps are used for detonating high explosives. They are designed for insertion into cap wells, and are also the detonating element in certain firing devices. Blasting caps are rated in power according to the size of their main charge. Commercial blasting caps are normally No. 6 or No. 8 and are used to detonate the more sensitive explosives, such as, commercial dynamite and tetryl. Special military blasting caps (M6 and M7) or their commercial counterparts (J1 and J2) are used to insure positive detonation of the generally less sensitive military explosives. Their main charge is approximately double that of the commercial No. 8 blasting cap. Both military and commercial blasting caps, being extremely sensitive, may explode unless handled carefully. They must be protected from shock and extreme heat and not tampered with. Blasting caps must never be stored with other explosives, nor should they be carried in the same truck except in an emergency (para 5–5). Two types, electric and nonelectric, are used in military operations.

*a. Electric Blasting Caps.* These are used when a source of electricity, such as a blasting machine or a battery, is available. Two types are in use, military and commercial (fig 1–22). Military caps are instantaneous, and the commercial caps are instantaneous and delay. Commercial delay caps (fig 1–22) are available with delays ranging from 0.025 second to 12 seconds. Delay caps used in military applications have delays ranging from 1.00 second to 1.53 seconds. Electric caps have lead wires of various lengths for connection into a circuit. The most commonly used are 12 feet long. To prevent accidental firing, they have a short circuiting shunt which must be removed before using the cap. If the cap is without a shunt, the bare ends of the lead wires may be twisted together to provide the shunting action. The M6 special electric blasting cap is the standard issue electric blasting cap. For further information see TM 9–1375—200.

*b. Nonelectric Blasting Caps.* Nonelectric blasting caps (fig 1–23) may be initiated by time blasting fuse, firing devices, and detonating cord. They should not be used to prime charges placed under water or in wet boreholes because they are difficult to waterproof. If it is necessary, however, they should be moisture-proofed with waterproof sealing compound. Those in use include commercial J1, No. 6 and No. 8, the military special nonelectric M7, and I(J–1). The M7 special nonelectric blasting caps are flared at the open end for easy insertion of the time fuse and are the standard issue nonelectric blasting caps. For further information see TM 9–1375–200.

## 1–45. Priming Adapter M1A4

This is a plastic hexagonal-shaped device threaded to fit threaded cap wells and the M10 universal explosive destructor. A shoulder inside the threaded end is large enough to accept time blasting fuse and detonating cord but too small to permit passage of a military blasting cap. The adapter is slotted longitudinally to permit easy and quick insertion of the electric blasting cap lead wires (fig 1–24). The M1A4 replaces the M1A2 and M1A3 models, which have cylindrical bodies. The hexagonal M1A4 is more readily handled by men wearing arctic mittens.

## 1–46. Blasting Cap Holder, M8

This is a metal clip designed to attach and hold a blasting cap to sheet explosive and is supplied with the M118 sheet demolition charges and the M186 roll demolition charge (fig 1–25). The M8 blasting cap holder is also available as a separate item of issue in quantities of 4,000.

## 1–47. Adhesive Paste, M1

This is a sticky, putty-like substance for attaching charges to vertical or overhead flat surfaces. It is useful in holding charges while tying them in place or, under some conditions, for holding without tying. It will not adhere satisfactorily to dirty, dusty, wet or oily surfaces, and becomes stiff and hard and loses its adhesiveness at subzero temperatures. It is softened by water and becomes useless if wet.

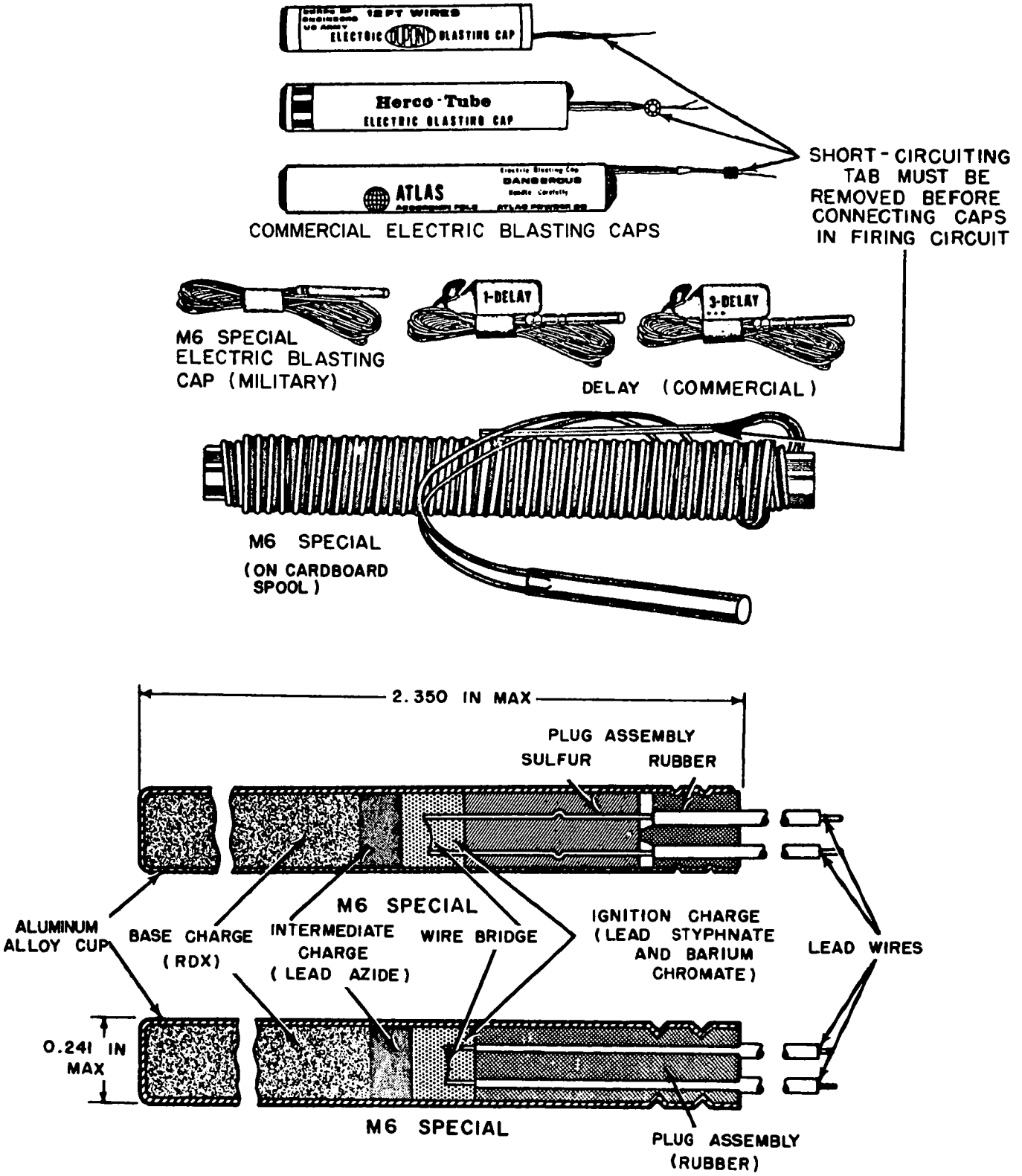
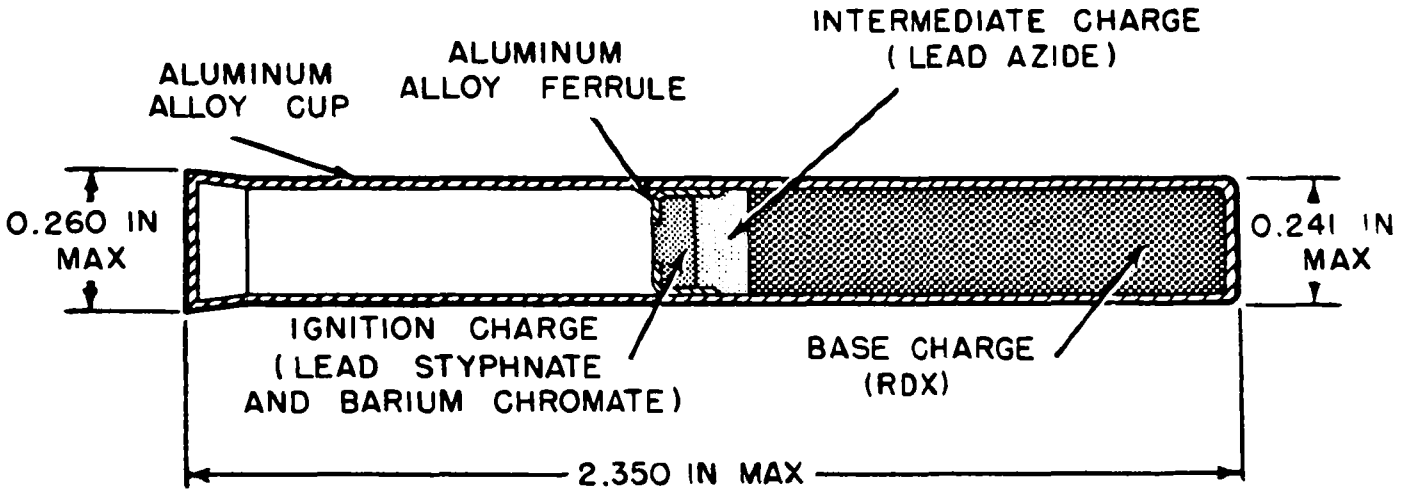
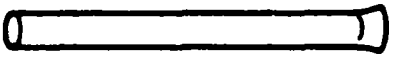


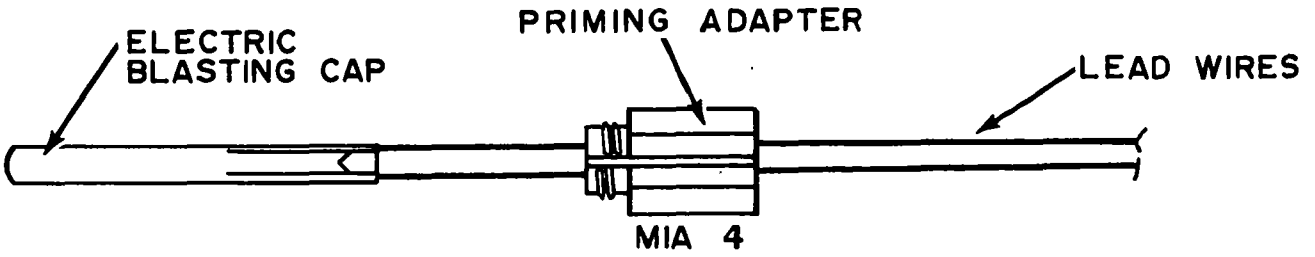

*Figure 1-22. Electric blasting cap.*



M7 SPECIAL NONELECTRIC BLASTING CAP (MILITARY)

*Figure 1-23. Military nonelectric blasting cap.*



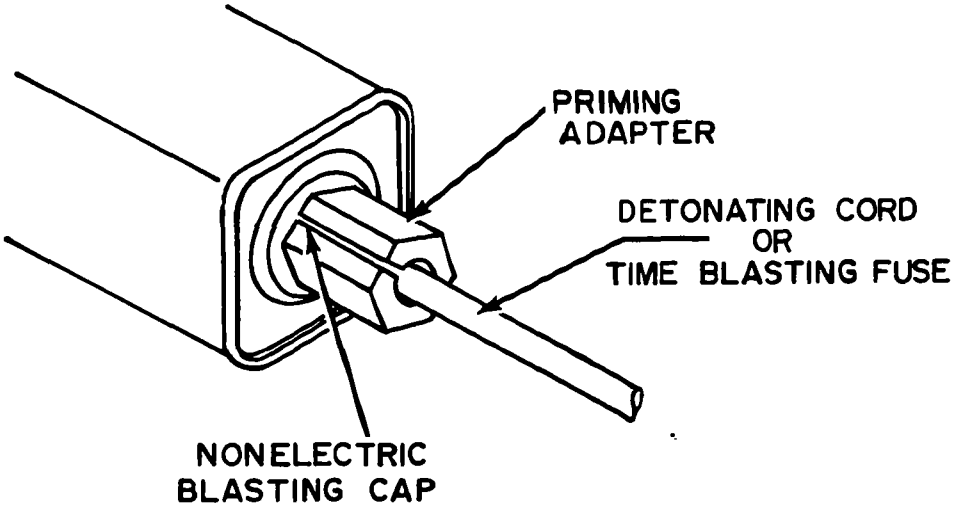




*Figure 1-24. M1A4 priming adapter.*

*Figure 1–25. M8 blasting cap holder.*

## 1–48. Tape, Pressure-Sensitive Adhesive Film

*a.* This tape is replacing Adhesive Paste, M1 and is superior in speed and ease of application, as well as holding power. It is used to hold demolition charges to dry, clean wood, steel, or concrete.

*b.* The tape is coated on both sides with pressure-sensitive adhesive and requires no solvent or heat to apply. It is available in rolls 2-inches wide and 72 yards long.

*c.* The tape will not adhere to dirty, wet or oil surfaces and is not to be used when surface temperature of the target is below freezing.

*d.* The tape is a component of newer blasting demolition sets described in paragraph 1–58.

## 1–49. Adhesive, Supplementary, for Demolition Charge, Tube

*a.* This supplementary adhesive is used to hold demolition charges when target surface is below freezing, wet, or underwater. The adhesive is issued in a tube in water-resistant, cardboard, slide boxes packaged with wooden applicators (fig 1–26), and shipped 150 boxes in a fiberboard container.

*b.* The adhesive is applied to the target surface with a wooden applicator and a demolition block with or without pressure-sensitive tape placed on top.

## 1–50. Waterproof Sealing Compound

This is used to waterproof the connection between the time blasting fuse and a nonelectric blasting cap and to moistureproof primed dyna-

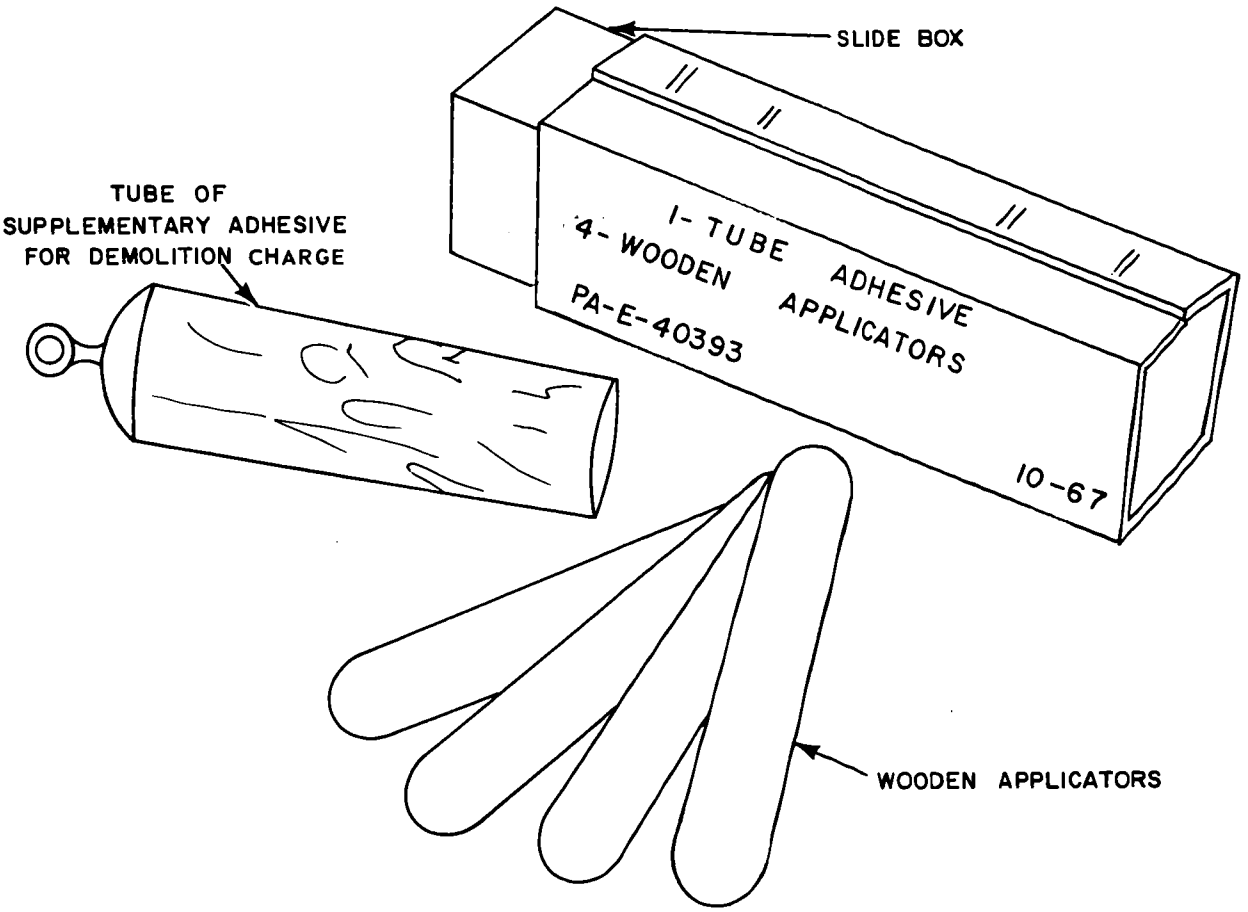



*Figure 1-26. Supplementary adhesive for demolition charge.*

mite. It does not make a permanent waterproof sea and must not be submerged in water unless the charge is to be fired immediately.

## 1–51. Cap Crimper, M2

The M2 cap crimper (fig 1–27) is used to squeeze the shell of a nonelectric blasting cap around time blasting fuse, a standard base, or detonating cord securely enough to keep it from being pulled off but not tightly enough to interfere with the burning of the powder train in the fuse or the detonation of the detonating cord; a stop on the handle limits the closing of the jaws to prevent this. The M2 crimper forms a water resistant groove completely around the blasting cap; however, sealing compound should be applied to the crimped end of the blasting cap for use under water. The rear portion of each jaw is shaped and sharpened for cutting fuse and detonating cord. One leg of the handle is pointed for use in punching cap wells in explosive materials for the easy insertion of blasting caps. The other leg has a screwdriver end. Cap crimpers, being made of a soft nonsparking metal (which will conduct electricity), must not be used as pliers for any purpose, as this damages the crimping surface. Also the cutting jaws must be kept clean and be used only for cutting fuse and detonating cord.

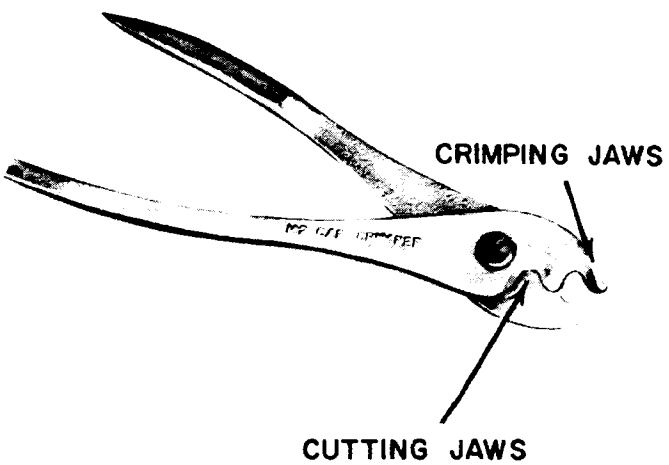



*Figure 1–27. M2 cap crimper.*

## 1–52. Blasting Galvanometer

*a.* The blasting galvanometer (fig 1–28) is an instrument used in testing the electric firing system to check the continuity of the circuit (the blasting cap, firing wire, wire connections, and splices) in order to reduce the possibility of misfires. Its components include a d'arsoval movement meter, and a small special silver-chloride dry-cell battery. When the two external terminals are connected in a closed circuit, the flow of current from the dry-cell moves the needle across the scale. The extent of the needle deflection depends on the amount of resistance in the closed circuit and on the strength of the battery. The galvanometer must be handled carefully and kept dry. It should be tested before using by holding a piece of metal across its two terminals. If this does not cause a wide deflection of the needle (23 to 25 units) the battery is weak and should be replaced. Being delicate, the instrument must not be opened except to replace a weak cell.

*b.* Two types of dry cell batteries authorized for use with this galvanometer are—

*BA–245/u Special Silver Chloride Dry-Cell; 0.9v total voltage; FSN 6135–128–1632; authorized for use at temperatures ABOVE 0° F.,*

and

*BA–2245/u Special Silver Chloride Dry-Cell; 0.9v total voltage; FSN 6135–833–9909; authorized for use at temperatures BELOW 0° F.*

*c.* When using the galvanometer at extreme cold temperatures, low temperature battery BA–2245/u is recommended. Battery BA–245/u will freeze and cease to function at temperatures below 0°F. Therefore, if BA–245/u is used at extremely cold temperature, protect it from freezing by placing galvanometer under the clothing near the body. When using the galvanometer at temperatures above 32° F., battery BA–245/u is recommended since low temperature battery BA–2245/u deteriorates rapidly at higher temperatures, even when not in use.

***Caution.*** **Only the two special silver-chloride dry-cell batteries BA–245/u and BA–2245/u, which produce only 0.9 volts, are to be used in the galvanometer, as other batteries may produce sufficient voltage to detonate electric blasting caps. Because of the tendency to corrode, the batteries should be removed from the galvanometer when it is not to be used for extended periods.**

## 1–53. Test Set, Blasting Cap: M51

*a.* This test set (fig 1–29) was developed to replace the blasting galvanometer for continuity testing of electrical firing circuits. The test set

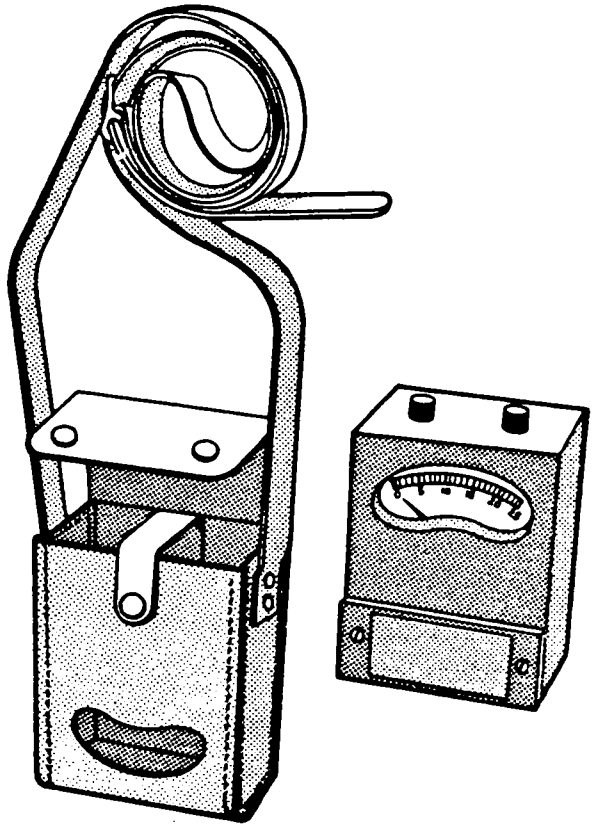


*Figure 1–28. Blasting galvanometer.*

is a self-contained unit with a magneto-type impulse generator, an indicator lamp, a handle to activate the generator, and two binding posts for attachment of firing leads. The test set is waterproof and may be used at temperatures as low as −40° F.

*b.* To assure optimum useful life, keep test set dry and handle with care. Before using, assure that set is in operating condition as follows:

(1) Connect a piece of bare wire between the binding posts.

(2) Sharply depress handle while observing indicator lamp. If set is operative, lamp will flash.

(3) Remove wire and proceed to test firing circuit.

*c.* Continuity testing is accomplished by connecting firing circuit to test set binding posts and then depressing handle sharply. If there is a continuous (intact) circuit (even one created by a short), indicator lamp will flash.

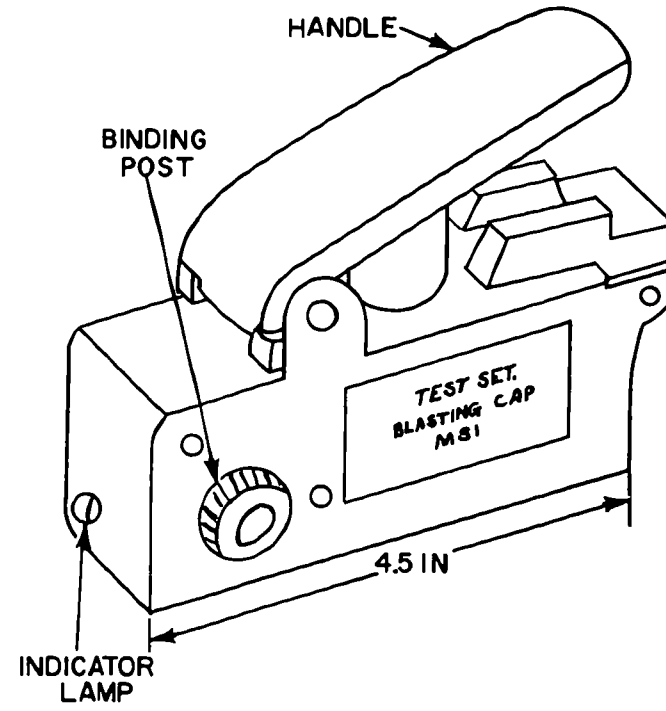



*Figure 1–29. M51 blasting cap test set.*

## 1–54. Blasting Machines

*a. Ten-Cap Blasting Machine.* This is a small DC electrical generator that produces adequate current (1.5 amperes) to initiate 10 electric caps connected in series if the handle is rotated to the end of its travel. It weighs approximately 5 pounds (fig 1–30). The operation is as follows:

(1) Try the machine to see whether or not it works properly. Using the procedure in (3) through (5) below, operate it several times until it works smoothly before attaching the firing wires.

(2) Fasten the firing wires tightly to the terminals.

(3) Insert the handle.

(4) Insert the left hand through the strap and grasp the bottom of the machine.

(5) Grasp the handle with the right hand and *turn it vigorously clockwise as far as possible.*

*b. Thirty-Cap Blasting Machine.* This device fires 30 electric caps connected in series. It weighs about 20 pounds. To operate:

(1) Raise the handle to the top of the stroke.

(2) Push the handle down quickly as far as it will go.

*c. Fifty-Cap and One Hundred-Cap Blasting Machines.*

(1) The 50-cap machine fires 50 electric caps connected in series (fig 1–30). It weighs about 20 pounds. Operation is as follows:

(*a*) Raise the handle to the top of its stroke.

(*b*) Push the handle down quickly as far as it will go.

(2) The 100-cap machine is similar to the 50-cap machine except for size and weight and is operated in the same manner. Both are adequate for firing their rated capacity of electric blasting caps connected in series.

## 1–55. Firing Wire and Reels

*a. Types of Firing Wire.* Wire for firing electric charges is issued in 500-foot coils. It is the two conductor, AWG No. 18 plastic-covered or rubber-covered type. It is carried on the reel unit RL39A, described below. Single-conductor AWG No. 20 annunicator wire in 200-foot coils is issued for making connections between blasting caps and firing wire. WD–1/TT communication wire may also be used, but it has a higher resistance which increases the power requirement so blasting machines cannot be used with the full rated number of caps with this wire. As a rule of thumb, use 10 caps less than the

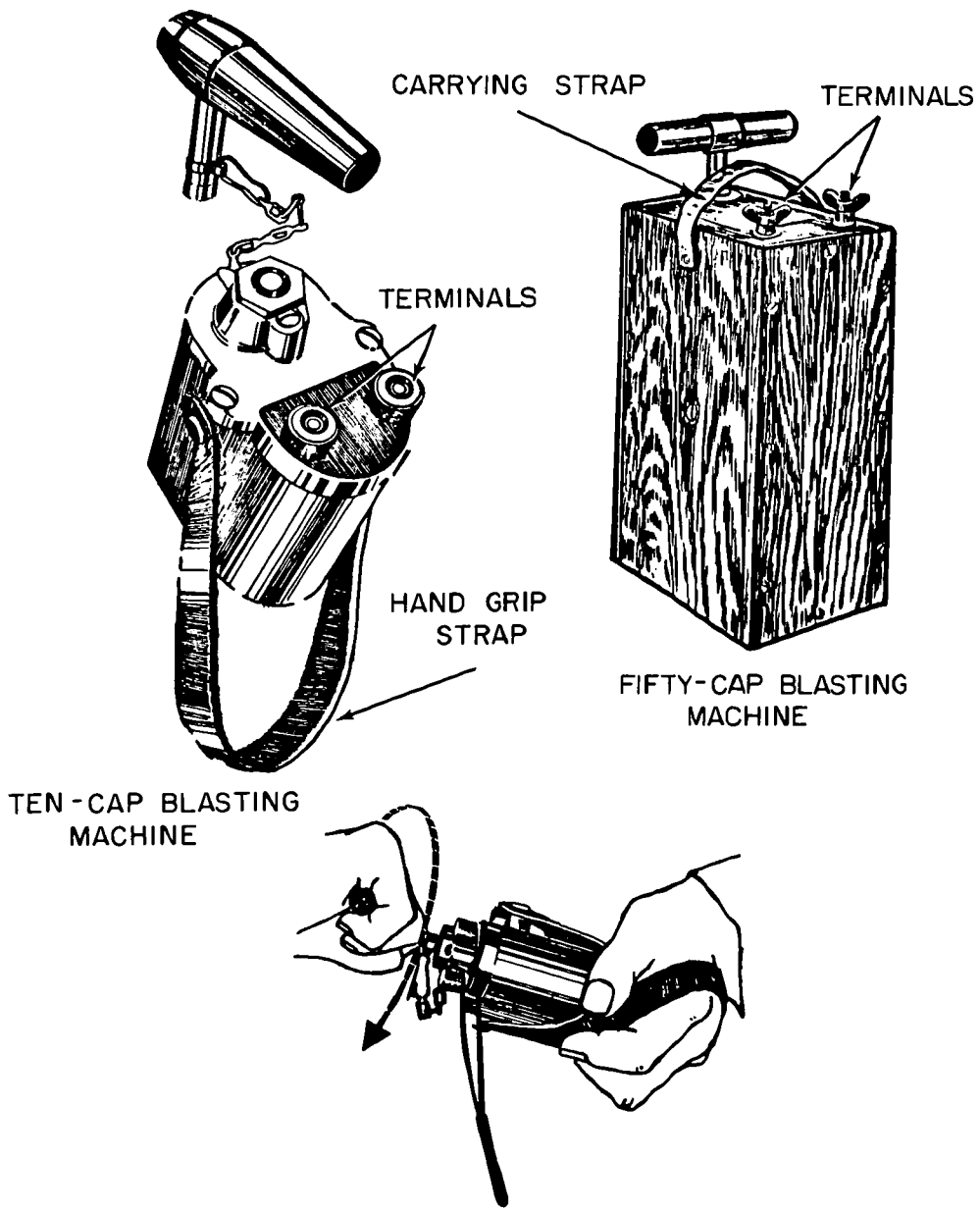



*Figure 1–30. Blasting machines.*

machine rating for each 1,000 feet of WD–1 wire use. For electrical characteristics of firing wire see appendix E.

*b. Reels.*

(1) *RL39A.* This consists of a spool that accommodates 500 feet of wire, a handle assembly, a crank, an axle, and two carrying straps (fig 1–31). The fixed end of the wire is extended from the spool through a hole in the side of the drum and fastened to two brass thumbnut terminals. The carrying handles are made of two U-shaped steel rods. A loop at each end encircles a bearing assembly, which is a brass housing with a steel center to accommodate the axle. The crank is riveted to one end of the axle and a cotter pin is placed in the hole at the other to hold the axle in place.

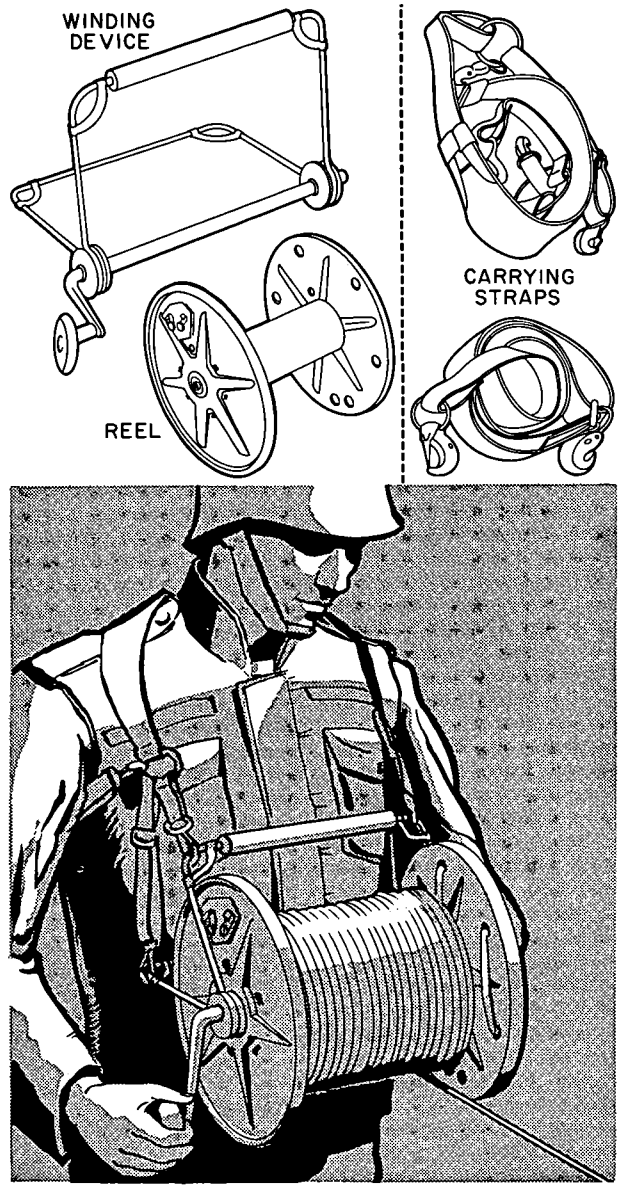



*Figure 1–31. Firing wire reel.*

(2) *500-foot reel with detachable handles.* This is a metal drum mounted on an axle to which two detachable D-shaped handles are fastened. The arm with the knob on the side of the drum is used for cranking (fig 1–32).

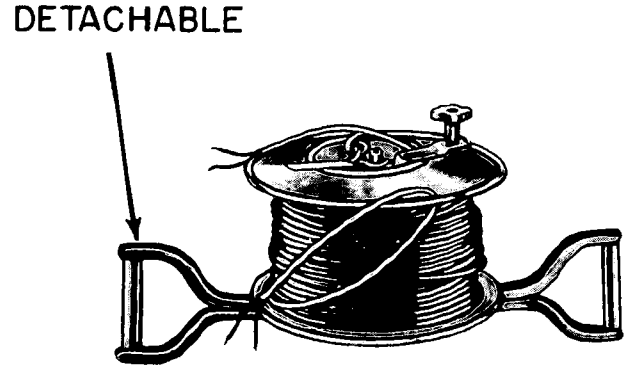



*Figure 1–32. Reel with detachable handles.*

(3) *1,000-foot reel.* This is similar to (2) above, except that it has a capacity of 1,000 feet of firing wire.

## 1–56. Detonating Cord Clip

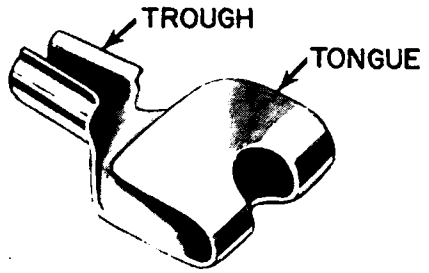
The M1 detonating cord clip (fig 1–33) is used to hold together two strands of detonating cord either parallel or at right angles to each other. Connections are made more quickly with these clips than with knots. Also, knots may loosen and fail to function properly if left in place any length of time. Joints made with clips are not affected by long exposure.

*a. Branch Line Connections.* Branch lines of detonating cord are connected by clipping the branch line with the U-shaped trough of the clip, and the main line with the tongue of the clip, as shown in figure 1–33.

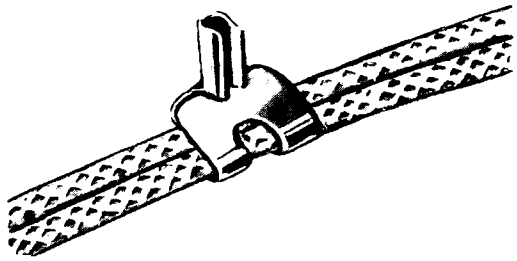
*b. Connecting Two Ends.* Ends of detonating cord are spliced by overlapping them about 12-inches, using two clips, one at each end of the overlap, and bending the tongues of the clips firmly over both strands. The connection is made secure by bending the trough end of the clip back over the tongue (fig 1–33).

## 1–57. Firing Devices and Other Accessory Equipment

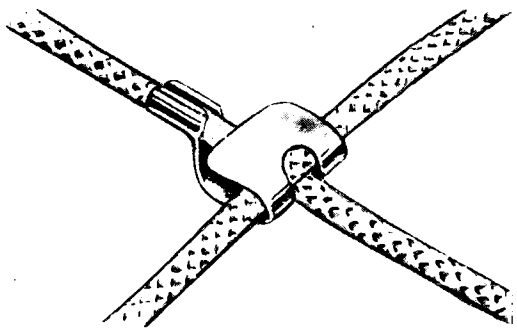
*a. M10 Universal Explosive Destructor.* The M10 destructor is a high explosive charge in




CLIP BEFORE BENDING



SPLICING TWO CORDS



BRANCH LINE CONNECTION

*Figure 1–33. M1 detonating cord clip.*

an assembled metal device initiated by means of blasting caps or mine activators with standard firing devices. The destructor has booster cups containing tetryl pellets. The chief function of the destructor is the conversion of loaded projectiles and bombs to improvised demolition charges and the destruction of abandoned ammunition (fig 1–34). For detailed description see TM 9–1375–200.

*b. M19 Explosive Destructor.* This device (fig 1–35) consists of an explosive-filled cylindrical body with a removable tip assembly which may be discarded if not needed. This destructor may be primed with a delay detonator, delay firing

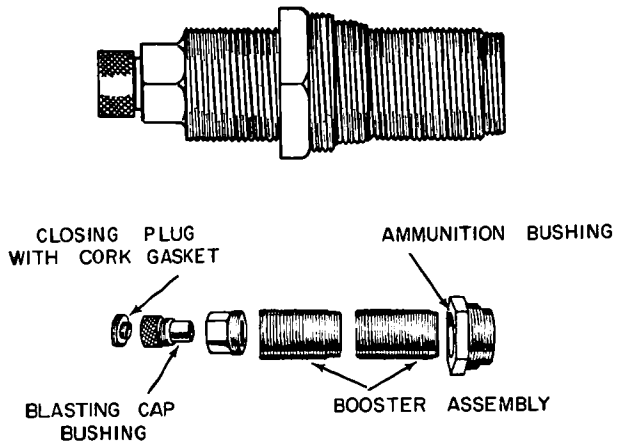



*Figure 1–34. M10 universal explosive destructor.*

device with a high output blasting cap, a nonelectric high output blasting cap initiated by time blasting fuse or detonating cord, or an electric high output blasting cap. The cap well on each end is threaded to receive the standard base coupling or a priming adapter. This device is particularly suitable for use as a dust initiator, described in appendix D, and similar charges.

*c. M1 Concussion Detonator.* The M1 concussion detonator is a mechanical firing device actuated by the concussion wave of a nearby blast (fig 1–36). It fires several charges simultaneously without connecting them with wire or detonating cord. A single charge fired in any way in water or air will detonate all charges primed with concussion detonators within range of the main charge or of each other (table 1–7). The base of the detonator is threaded to fit all standard cap wells in demolition blocks and explosive devices. Detonators frequently function at ranges greater than those in table 1–7, but their reliability is then not assured. For safety reasons it should not be used in surf at depths greater than 15 feet because it will function by hydrostatic pressure at a depth of 25 feet. Further, if the salt delay pellet is crumbled due to long storage, the detonator should *not* be used on underwater charges. For details of functioning and use see TM 9–1375–200.

*d. M1A1 15-Second Delay Friction Detonator.* This device (fig 1–37) consists of a pull friction fuse igniter, a 15-second pyrotechnic delay element, and a blasting cap. The blasting cap is protected by a cap screwed on the base. To install the detonator simply remove the cap protector from the base and screw it into the threaded cap well of the demolition block or explosive device.

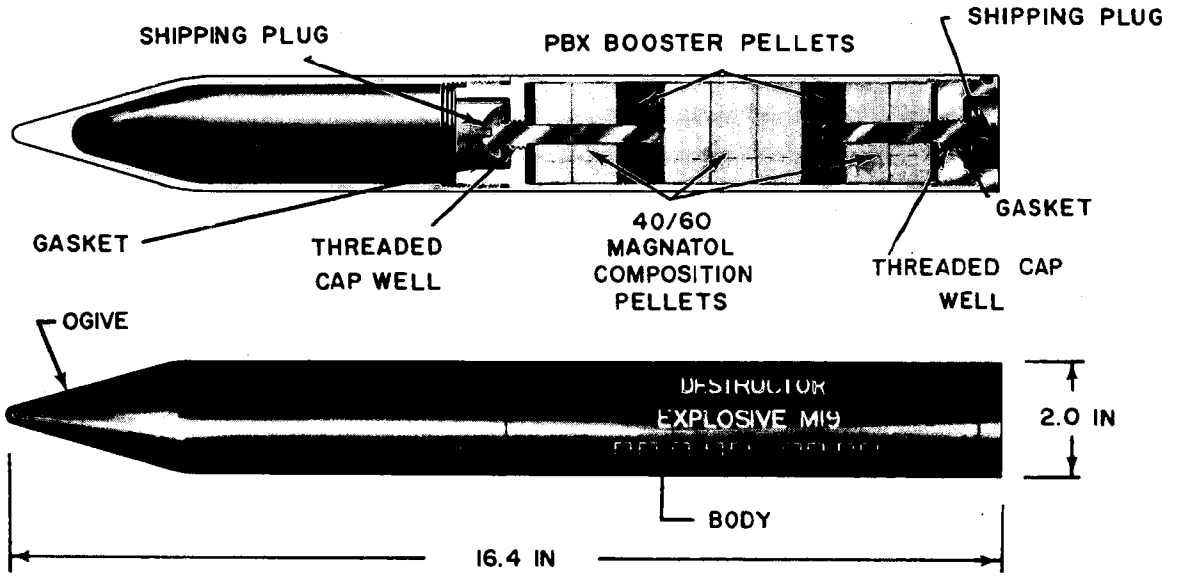



*Figure 1–35. M19 explosive destructor.*

*Table 1–7. Operating Range of Concussion Detonators*

| Weight of initiating charge (lbs) | In water | | In air | |
|---|---|---|---|---|
| | Depth of water (ft) | Recommended range (ft | Recommended range (ft) | |
| | | | * p = 99% | * p = 99.9% |
| 0.5 | 2 | 10 | ------ | ------ |
| 0.5 | 4 | 50 | ------ | ------ |
| 0.5 | 6 | 80 | ------ | ------ |
| 0.5 | 8 | 80 | ------ | ------ |
| 2.5 | ------ | ------ | 12.5 | 10.8 |
| 2.5 | 2 | 20 | ------ | ------ |
| 2.5 | 4 | 80 | ------ | ------ |
| 2.5 | 6 | 90 | ------ | ------ |
| 2.5 | 8 | 150 | ------ | ------ |
| 5 | ------ | ------ | 14.1 | 11.5 |
| 10 | ------ | ------ | 18.8 | 15.7 |
| 15 | ------ | ------ | 21.5 | 18.0 |
| 20 | ------ | ------ | 25.2 | 21.2 |
| 20 | 2 | 20 | ------ | ------ |
| 20 | 4 | 80 | ------ | ------ |
| 20 | 6 | 180 | ------ | ------ |
| 20 | 8 | 260 | ------ | ------ |

* p = Probability that detonator at indicated distance will be caused to function by initiating charge.

*e. M1A2 15-Second Delay Percussion Detonator.* This detonator (fig 1–38) consists of a firing pin assembly joined to a delay housing and primer holding assembly. To install the percussion detonator remove the cap protector and screw the device into the threaded cap well of the demolition block or explosive device. This detonator replaces the M1A1 friction detonator (*d* above).

*f. M2 8-Second Delay Friction Detonator.* This detonator (fig 1–39) consists of a friction-type fuse lighter, an 8-second pyrotechnic delay element, and a blasting cap. The blasting cap is protected by a cap screwed on the base. To install the friction detonator unscrew the cap protector from the assembly. Then screw the detonator into the threaded cap well of the demolition block or explosive device.

*g. M2A1 8-Second Delay Percussion Detonator.* Except for the delay period, the marking, and shape of the pull ring, the 8-second delay percussion detonator is identical to that in *e* above, in construction, functioning, and installation (fig 1–40). This detonator replaces the M2 friction detonator (*f* above).

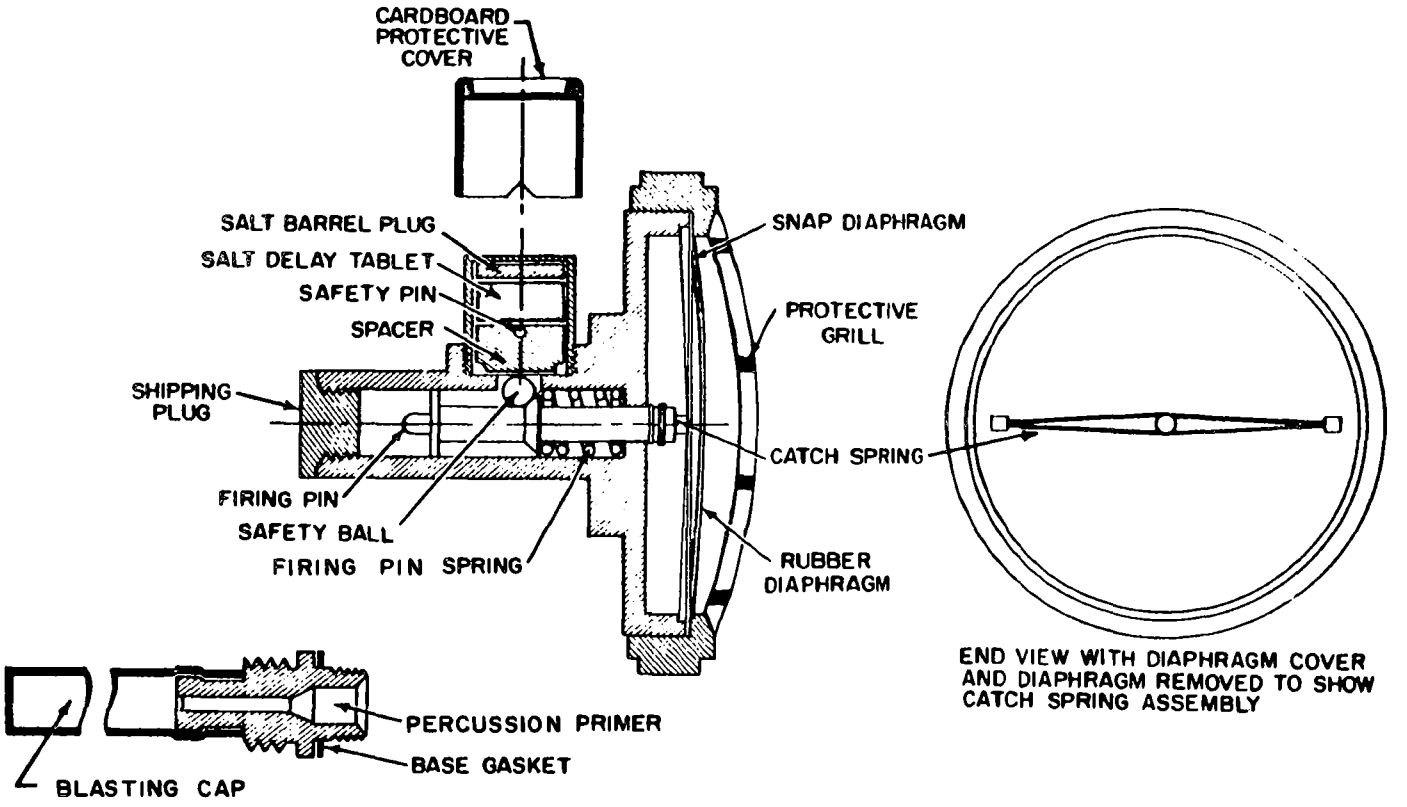
*h. M1 Delay Firing Device.* The M1 delay firing device is depicted in figure 1–40, and its characteristics are given in table 1–8. The proper steps of installation are:

(1) Select a device with proper time delay (table 1–9).

(2) Insert nail in inspection hole to make sure that firing pin has not been released. If the firing pin has been released, the nail cannot be pushed through the device.

(3) Remove protective cap from base.

(4) With crimper attach nonelectric blasting cap to base. *Crimper jaws should be placed*



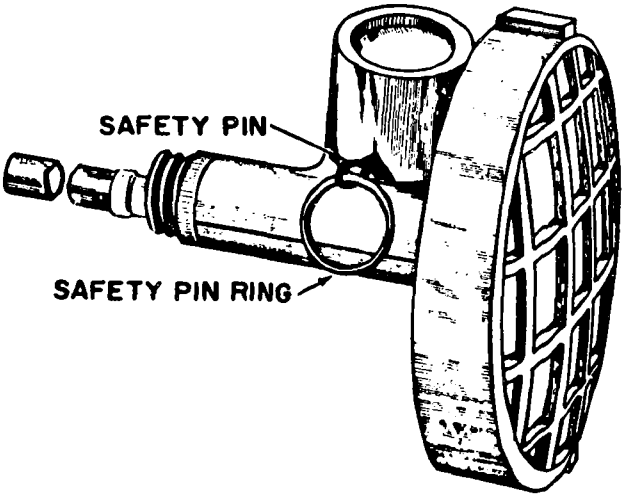




*Figure 1–36. M1 concussion detonator.*

*no further than ¼-inch from open ends of blasting cap.*

(5) Secure firing device in demolition charge or explosive device.

(6) Crush glass ampoule between thumb and fingers.

(7) Remove safety strip.

***Warning.*** **If the safety strip does not remove easily, do not force it. Remove and discard device without removing safety strip since the firing pin may have released or could be released by the handling required to remove a jammed strip.**

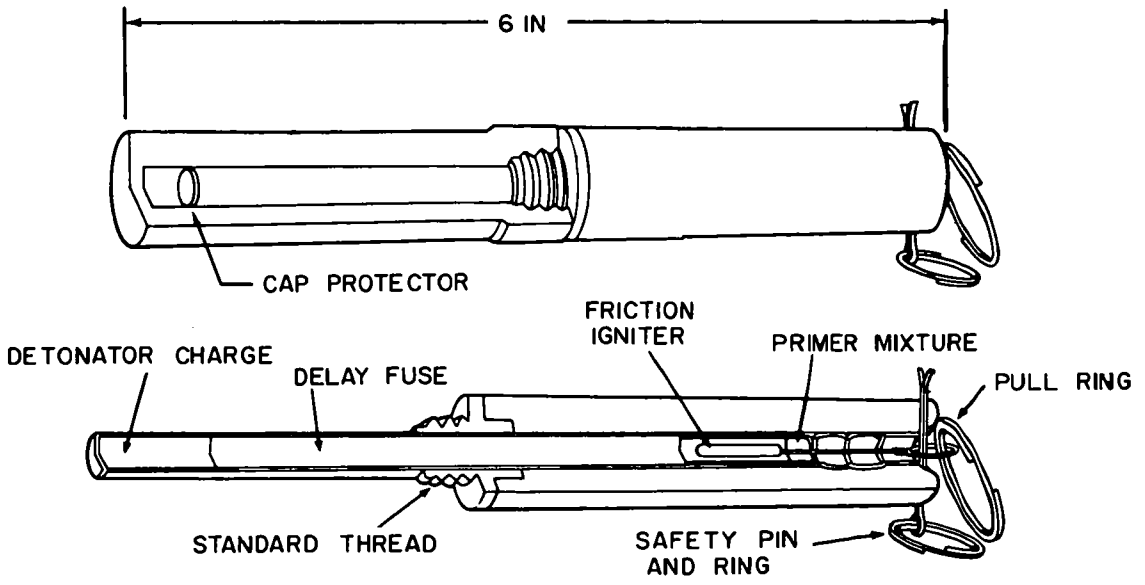



*Figure 1–37. M1A1 15-second delay friction detonator.*

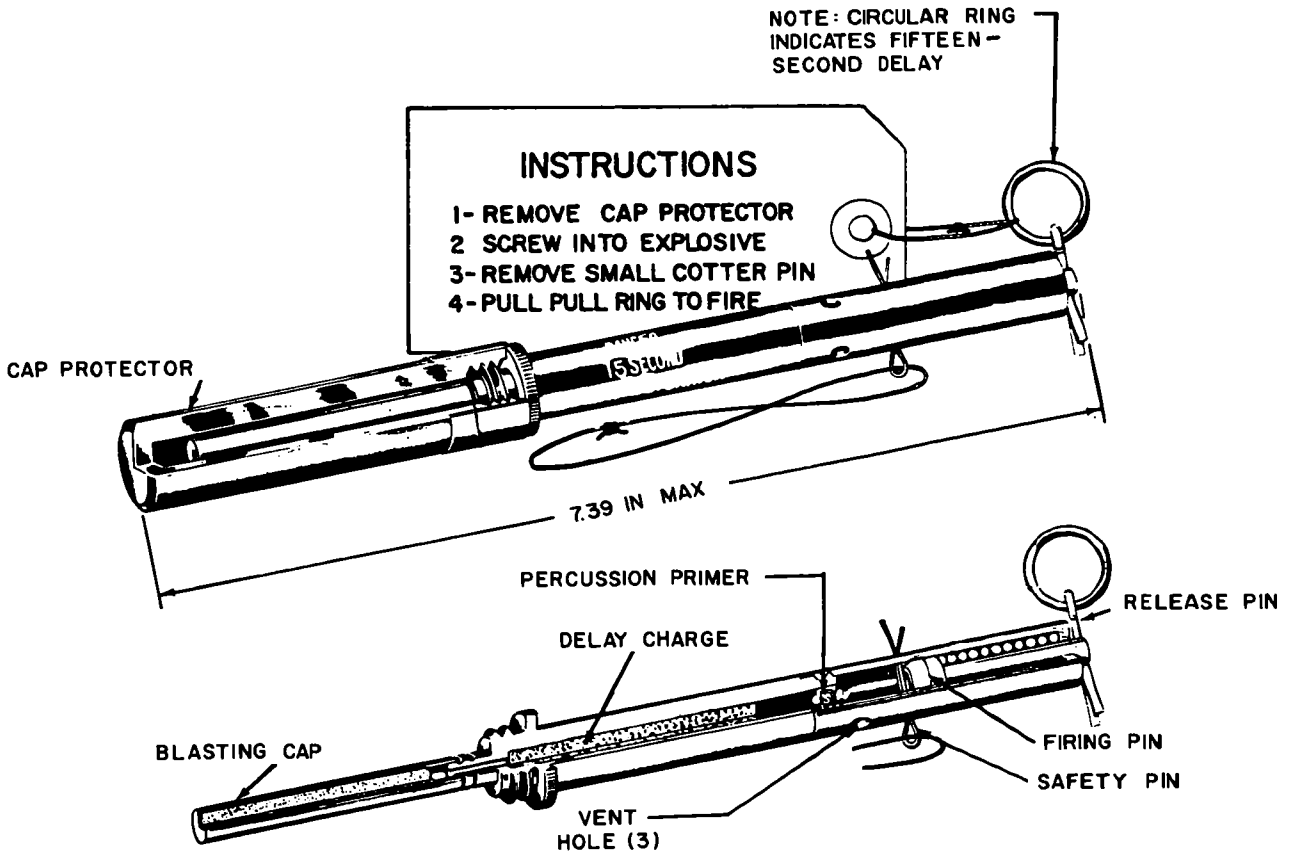



*Figure 1–38. M1A2 15-second delay percussion detonator.*

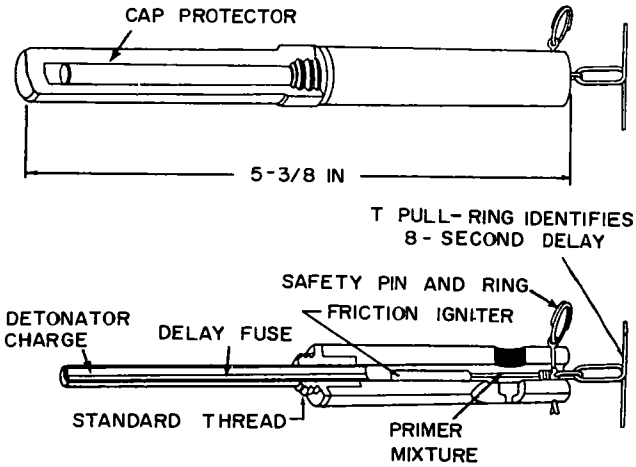



*Figure 1–39. M2 8-second delay friction detonator.*

*i. M1A1 Pressure Firing Device.* Figure 1–42 shows the M1A1 pressure firing device, and table 1–10 lists some of its characteristics. To install this device do the following:

(1) Remove protective cap from base and crimp on a nonelectric blasting cap. *Crimper jaws should be placed no further than ¼-inch from open end of blasting cap.*

(2) Assemble 3-pronged pressure head and extension rod and screw in top of pressure cap, if needed.

(3) Attach firing device assembly to demolition charge or explosive device.

(4) Remove safety fork first, and positive safety last.

*j. M1 Pull Firing Device.* Table 1–10 lists the characteristics of the M1 pull firing device. To install the device (fig. 1–43) do the following:

(1) Remove protective cap.

(2) With crimpers, attach nonelectric blasting cap to standard base. *Crimper jaws should be placed no father than ¼-inch from open end of blasting cap.*

(3) Attach firing device assembly to demolition charge or explosive device.

(4) Attach anchored pull wire.

(5) Remove *locking safety pin first, and positive safety pin last.*

*k. M3 Pull-Release Firing Device.* Character-

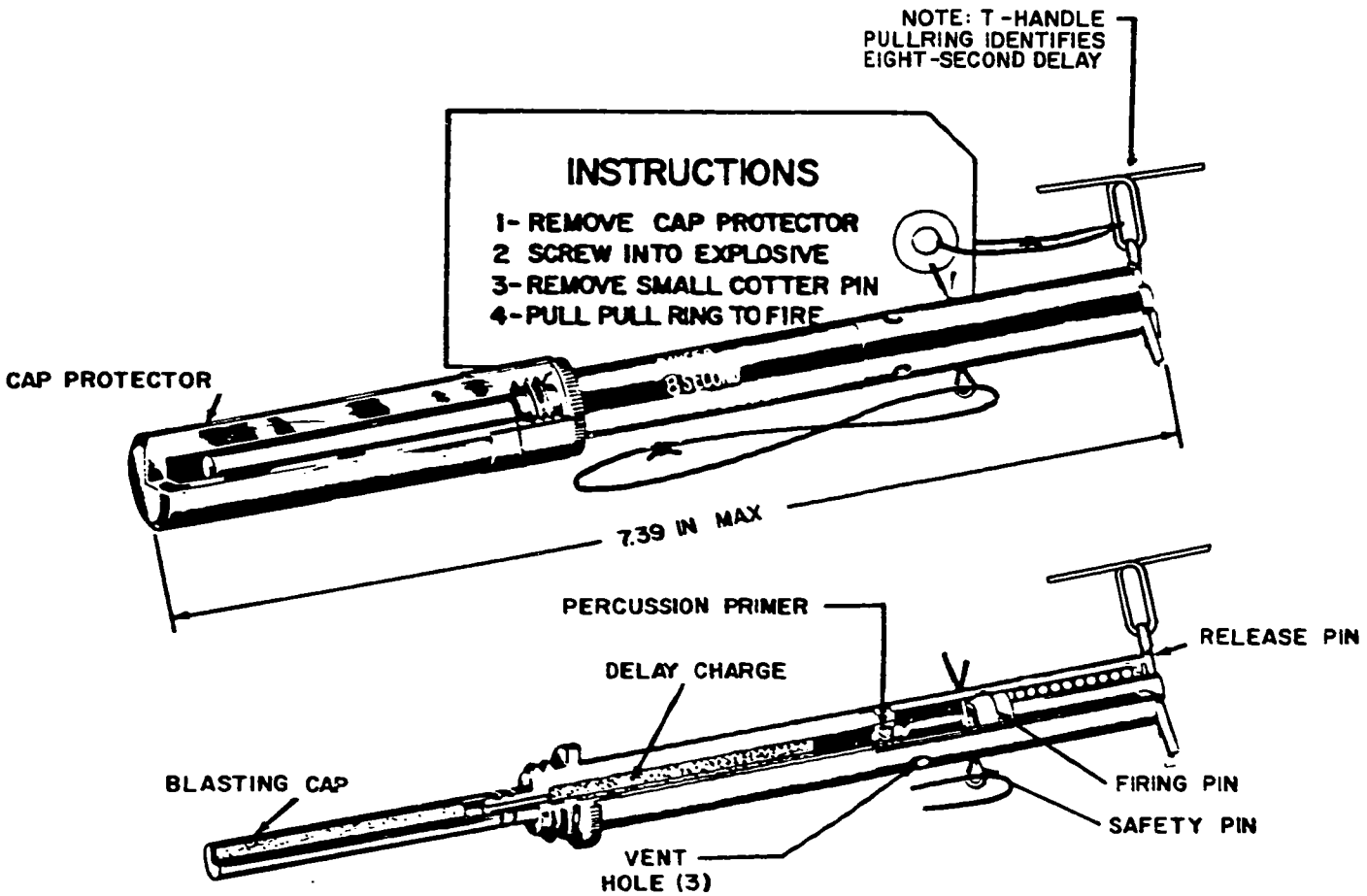



*Figure 1–40. M2A1 8-second delay percussion detonator.*

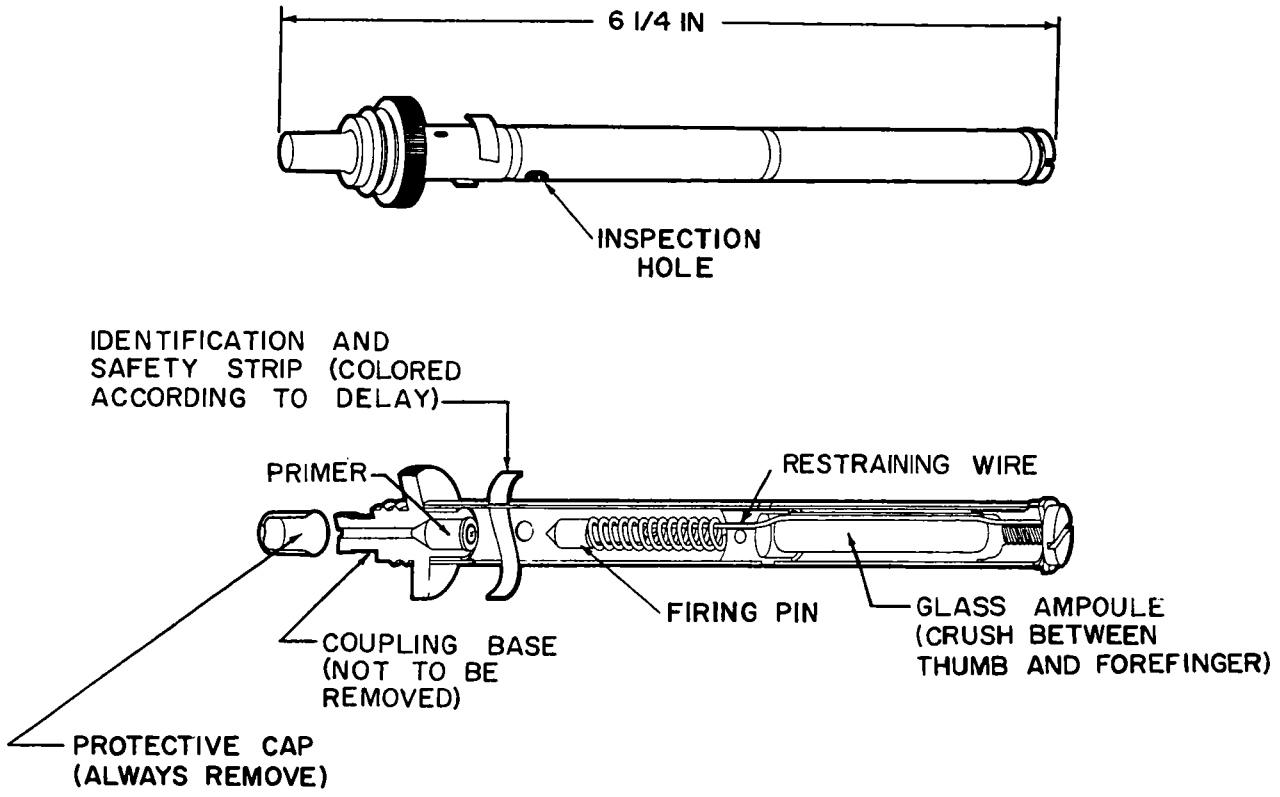



*Figure 1-41. M1 delay firing device.*

*Table 1-8. Characteristics of the M1 Delay Firing Device*

| Case | Color | Dimensions | | Internal action | Delay |
|---|---|---|---|---|---|
| | | Diameter | Length | | |
| Copper and brass | Natural metal | 7/16 in | 6¼ in | Mechanical with corrosive chemical release. | 1 min to 23 days, identified by color of safety strip. |

| Safety | Packaging |
|---|---|
| Colored metal strip inserted in slot above percussion cap. | 10 units—2 red, 3 white, 3 green, 1 yellow, and 1 blue—and a time delay table packed in paperboard carton, 10 cartons in fiberboard box, and 5 boxes in wooden box. |

*Table 1-9. Time Delay vs Temperature Effects for the M1 Delay Firing Device*

| Temp (deg F) | Black | | Red | | White | | Green | | Yellow | | Blue | | Temp (deg C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OM | ST | OM | ST | OM | ST | OM | ST | OM | ST | OM | ST | |
| −25 | | | 8.5 hr | 3.3 hr | 3 da | 1.3 da | | | | | | | −32 |
| 0 | 8 hr | 2.5 hr | 45 min | 20 min | 17.5 hr | 8 hr | 2.6 da | 1.2 da | 8.5 da | 3.8 da | 23 da | 10 da | −18 |
| +25 | 36 min | 16 min | 25 min | 11 min | 5.5 hr | 2.5 hr | 17 hr | 8 hr | 2.0 hr | 20 hr | 5.0 da | 2.2 da | −4 |
| 50 | 15 min | 7 min | 17 min | 8 min | 2 hr | 55 min | 6 hr | 2.7 hr | 14 hr | 6.0 hr | 1.3 da | 14 hr | +10 |
| 75 | 9 min | 4 min | 15 min | 7 min | 1 hr | 27 min | 2.5 hr | 70 min | 5.5 hr | 2.5 hr | 11.5 hr | 5 hr | 24 |
| 100 | 5 min | 2.0 min | 8 min | 3.5 min | 32 min | 14 min | 70 min | 30 min | 2.5 hr | 65 min | 5.2 hr | 2.3 hr | 38 |
| 125 | 4 min | 1.5 min | 5 min | 2 min | 20 min | 9 min | 35 min | 15 min | 80 min | 36 min | 2.5 hr | 1.1 hr | 52 |
| 150 | 3 min | 1 min | 4 min | 1.5 min | 15 min | 6 min | 20 min | 9 min | 46 min | 21 min | 80 min | 36 min | 66 |

OM—Most likely delay if two devices are used in the same charge. If only a single device is used, this value should be increased approximately 15 percent.

ST—Reasonable safe time. Delays of less than this value should not occur more than one in a thousand.

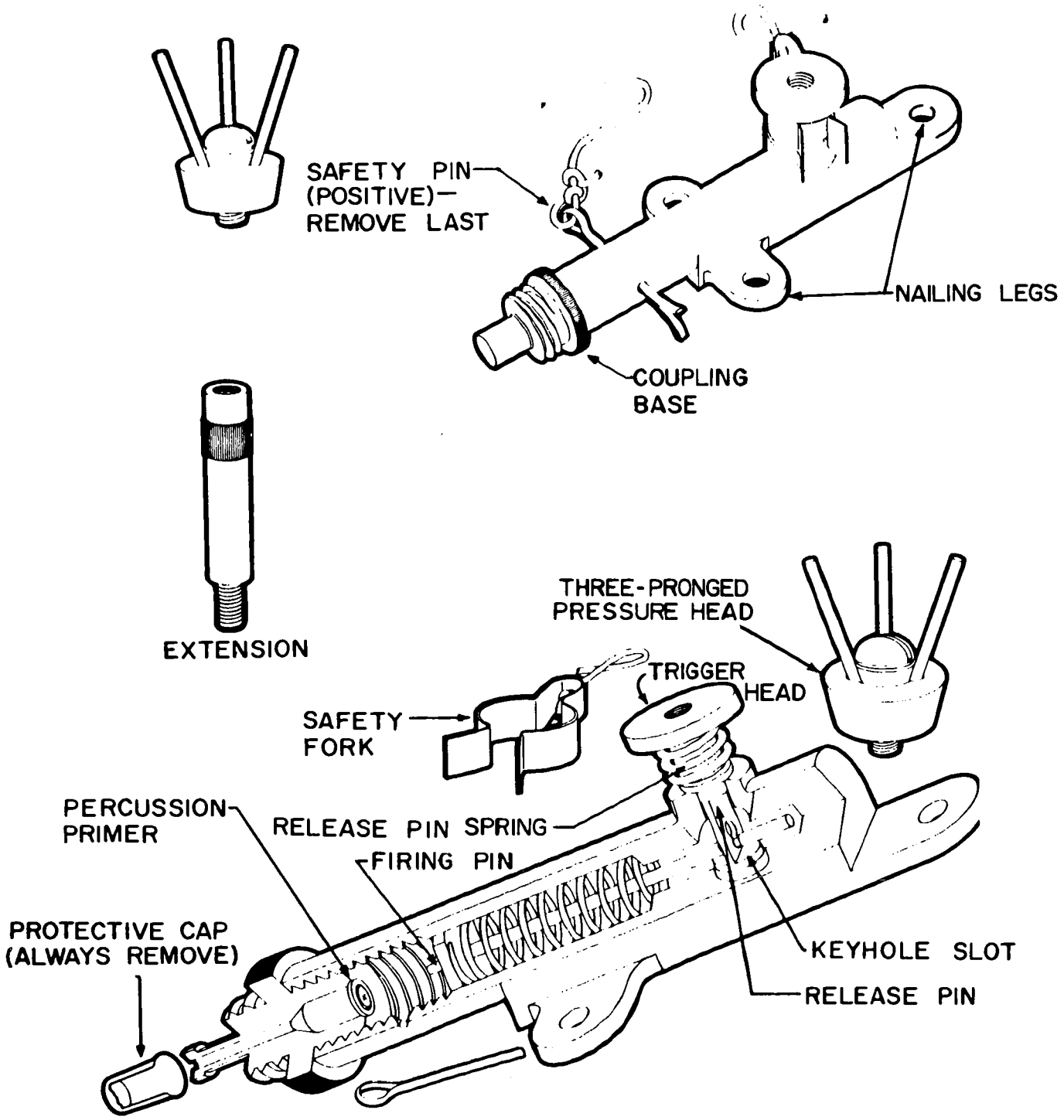



*Figure 1–42. M1A1 pressure firing device.*

istics of the M3 pull-release firing device are given in table 1–10 and figure 1–44. To install the device:

(1) Remove protective cap.

(2) With crimpers, attach blasting cap to standard base. *Crimper jaws should be placed no further than ¼-inch from open end of blasting cap.*

(3) Attach firing device to anchored charge (must be firm enough to withstand pull of at least 20 pounds).

(4) Secure one end of trip wire to anchor and place other end in hold in winch.

(5) With knurled knob, draw up trip wire until locking safety pin is pulled into wide portion of safety pin hole.

*Table 1–10. Characteristics of Firing Devices*

| Device | Case | Color | Dimensions (Inches) | | | Internal action | Operating pressure (lbs) |
|---|---|---|---|---|---|---|---|
| | | | Diameter | | Length | | |
| M1A1 | Metal | OD | 5/8 | | 2 3/4 | Spring-driven striker with trigger pin and keyhole slot release. | 20 or more. |
| M1 | Metal | OD | 9/16 | | 3 5/16 | Mechanical with split-head striker release. | 3 to 5 pull on trip wire. |
| M3 | Metal | OD | 9/16 | | 4 | Mechanical with spreading striker head release. | Direct pull of 6 to 10 and/or tension release. |
| M5 | Metal | OD | 1¾ length | 15/15 width | 11/16 height | Mechanical with hinged plate release. | Removal of restraining weight—5 or more. |

| Device | Safeties | Accessories | Packaging |
|---|---|---|---|
| M1A1 | Safety fork and positive safety pin. | 3-pronged pressure head and extension rod. | Five units, with percussion caps packed in cardboard carton. Fifty cartons shipped in wooden box. |
| M1 | Locking and positive safety pins. | | Five units complete with percussion caps and two 80-ft spools of trip wire are packed in chipboard container. Forty chipboard containers are packed in wooden box. |
| M3 | Locking and positive safety pins. | | Five units with two 80-ft spools of trip wire in carton, and 5 cartons packed in wooden box. |
| M5 | Locking safety pin and hole for improvised positive safety pin. | | Four firing devices complete and four plywood pressure boards in paper carton. Five cartons are packaged in fiber board box and ten of these in wooden box. |

(6) Remove *locking safety pin first* and *positive safety pin last.*

***Warning.*** **Do not attempt to neutralize firing device for recovery. Booby traps utilizing M3 firing device must be neutralized by blowing in place.**

*l. M5 Pressure Release Firing Device.* Table 1–10 and figure 1–45 show the characteristics of this device. To install the M5 pressure release firing device do the following:

(1) Insert a length of 10-gage wire in interceptor hole.

(2) Bend slightly to prevent dropping out.

(3) Remove small cotter pin from safety pin.

(4) Holding release plate down, replace locking safety pin with length of 16- or 18-gage wire. Bend wire slightly to prevent dropping out.

(5) Remove protective cap from base and with crimpers, attach the nonelectric blasting cap. *Crimper jaw should be placed no farther than ¼-inch from open end of blasting cap.*

(6) Secure firing device assembly in demolition charge or explosive device.

(7) Emplace charge and set the restraining weight, remove the improvised locking safety pin first and then the improvised positive safety pin from the interceptor hole. The pins should remove easily if the restraining weight is adequate and positioned properly.

*m. M2 Weatherproof Fuse Igniter.* This device was designed as a positive method of lighting time blasting fuse (fig 1–46). It operates effectively under all weather conditions—even under water if it is properly waterproofed. A pull on the striker retaining pin causes the striker to hit the primer, igniting the fuse. A sealing compound is applied between the fuse and the igniter to protect the open end of the fuse against moisture.

*n. M60 Weatherproof Fuse Igniter.* This device is designed to ignite time blasting fuse in all sorts of weather conditions and under water if waterproofed. The fuse is inserted through a sealing rubber grommet and into a split collet which clutches the fuse when the end cap on

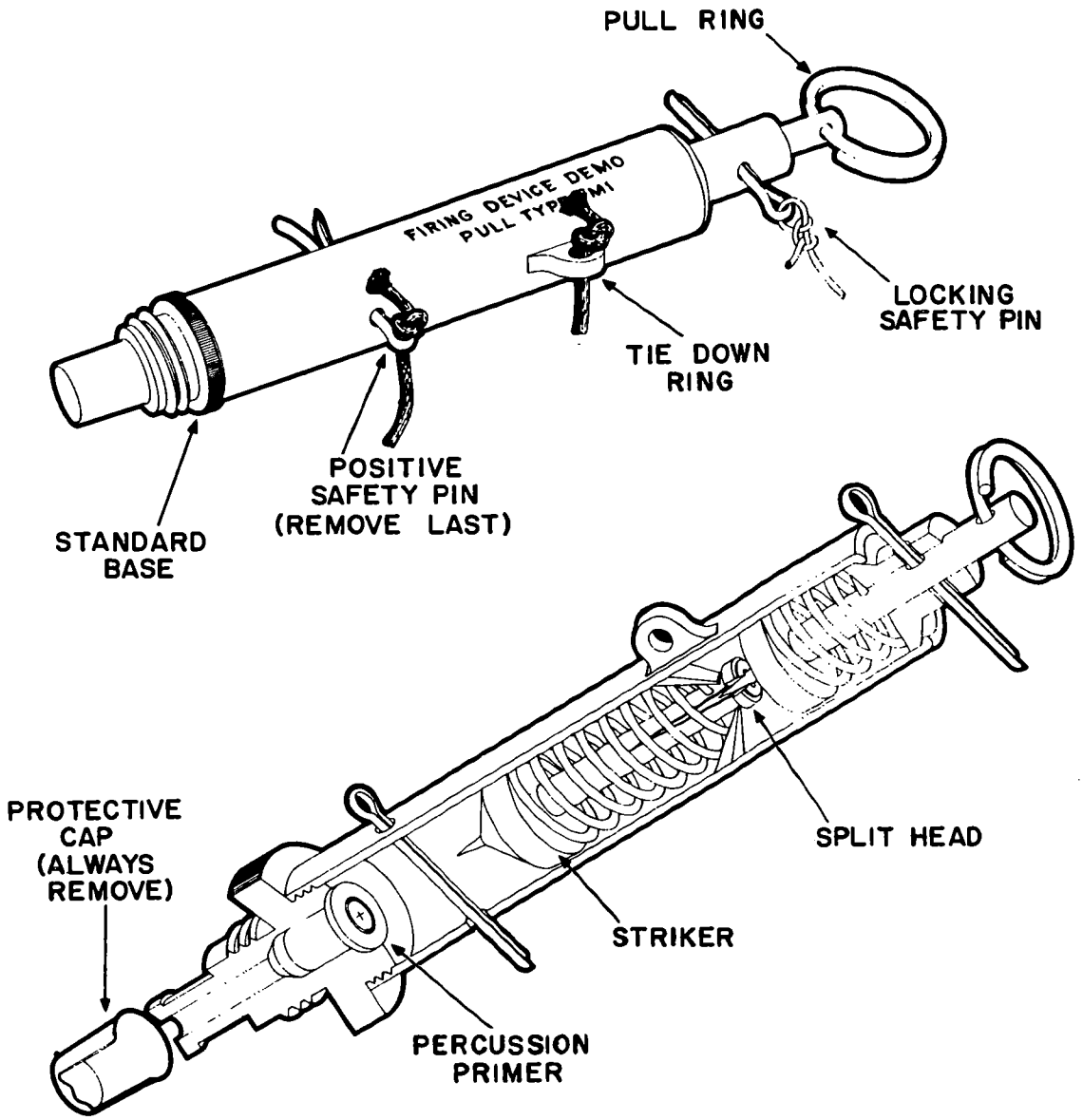



*Figure 1–43. M1 pull firing device.*

the igniter is tightened (fig 1–47). A pull on the pull ring releases the striker assembly, allowing the firing pin to drive against the primer, which ignites the fuse. For further information on its use, see paragraph 2–2*i*.

*o. Computing Tape.* Some demolition sets (para 1–58) contain a computing tape. The values on this tape are erroneous and the tape should not be used.

*p. Demolition Card.* This pocket sized card (GTA 5–10–9) gives data in tabulated form for the calculation of pressure, timber-cutting, steel-cutting, breaching, and cratering charges.

*q. Additional Tools.* In addition, tools such as earth augers and diggers, and pneumatic tools will be helpful to facilitate the placement of charges.

(1) *Hand-operated posthole auger.* The 10-inch posthole auger (A, fig 1–48) is capable of boring a hole large enough for the 40-pound ammonium nitrate cratering charge and other charges of equal size. The extension handle permits boring as deep as 8 feet.

(2) *Posthole digger.* This tool (B, fig 1–48) has two concave metal blades on hinged wooden handles. The blades are forced into the earth and the soil is removed by pulling the handles apart and lifting it out of the hole.

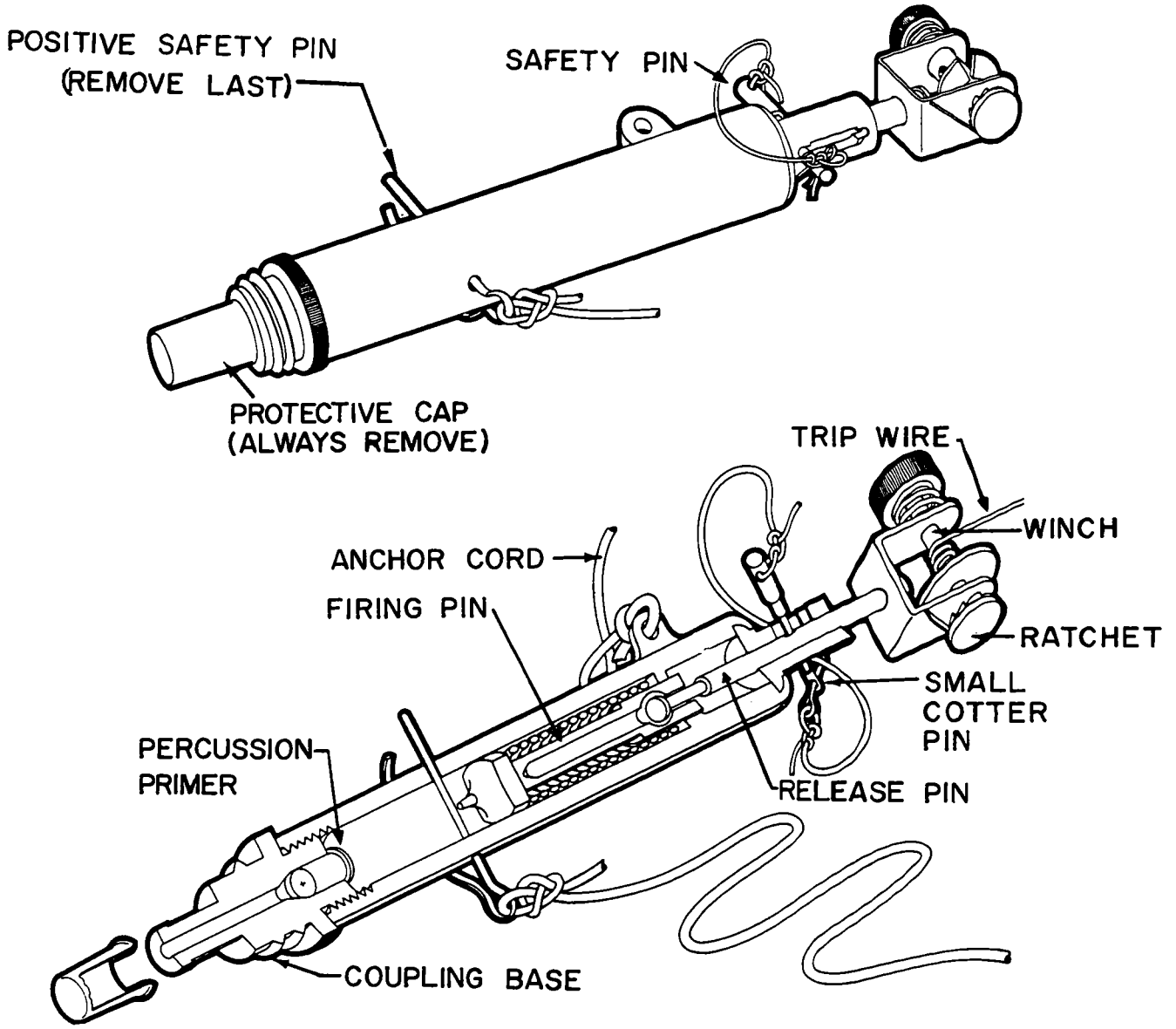



*Figure 1–44. M3 pull-release firing device.*

(3) *Motorized earth auger.* Motorized earth augers drill holes 8, 12, 16, or 20 inches in diameter to depths up to 8 feet.

(4) *Pneumatic tools.* These are the rock drill, pavement breaker, and wood-boring machine. The *rock drill* bores up to 2-inches in diameter in rock, concrete, or masonry for the placement of internal charges. The *pavement breaker* is used to shatter the hard surface of roads before drilling boreholes with an auger for cratering charges. The *wood-boring machine* drills boreholes in wood for the placement of internal charges.

## 1–58. Demolition Sets

These sets are assemblies of demolition explosive items, accessories, and tools needed to accomplish and initiate almost all demolition projects. They are issued according to tables of equipment.

*a. Demolition Set, Explosive Initiating, Electric and Nonelectric.* The electric and nonelectric demolition set consists of TNT and composition C4 demolition blocks and the demolition accessories and tools necessary for electric and nonelectric priming and firing (fig 1–49). The

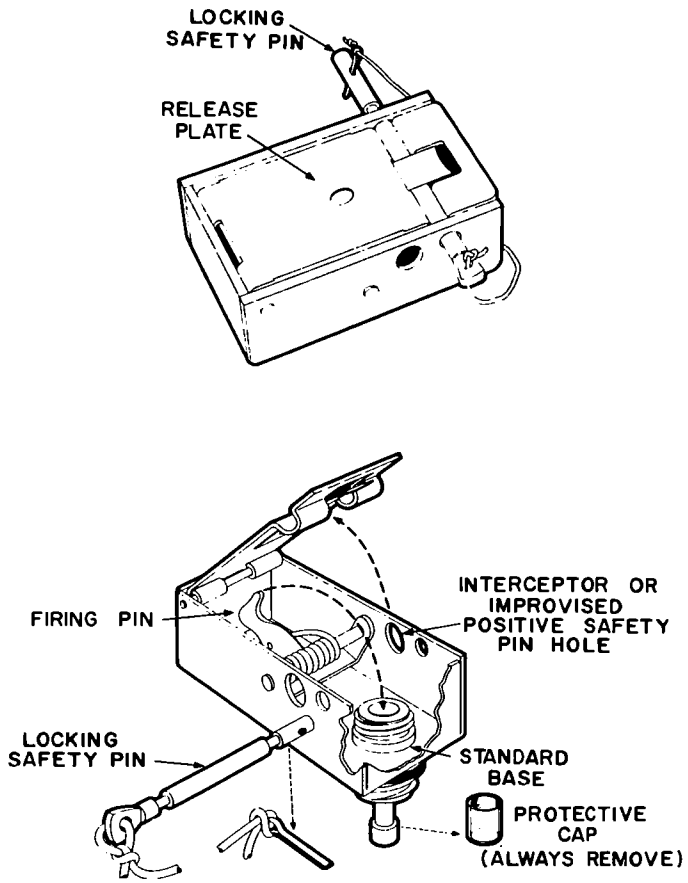



*Figure 1–45. M5 pressure-release firing device.*

set is issued and carried in a wooden demolition chest. The basic set consists of the items listed in (1) below.

(1) *Components issued as basic.* These items may be requisitioned separately for replacement purposes.

| *Quantity* | *Item* |
|---|---|
| 2 | BAG, CANVAS, CARRYING: demolition kit |
| 1 | BLASTING MACHINE: ten-cap capacity |
| 5 | BOX, CAP: ten-cap capacity, infantry |
| 1 | CHEST, DEMOLITION: engineer platoon, M1931 |
| 2 | CRIMPER, CAP: M2 (w/fuse cutter) |
| 1* | TEST SET, BLASTING CAP: M51 |
| 2 | KNIFE, POCKET |
| 2 | PLIERS: lineman's (w/side cutter), length 8-inch |
| 1 | REEL, WIRE: firing, 500 H, RL–39A, (w/carrying straps, w/winding device, w/spool, w/o wire) |
| 2 | TAPE, COMPUTING: demolition charge |

*Note.* Older demolition sets will contain the blasting galvanometer and battery BA–245/u instead of the blasting cap test set M51.

(2) *Components issued separately.* The following items are required to complete the demolition set and should be on hand at all times. These items are not supplied with the set, and must be requisitioned separately.

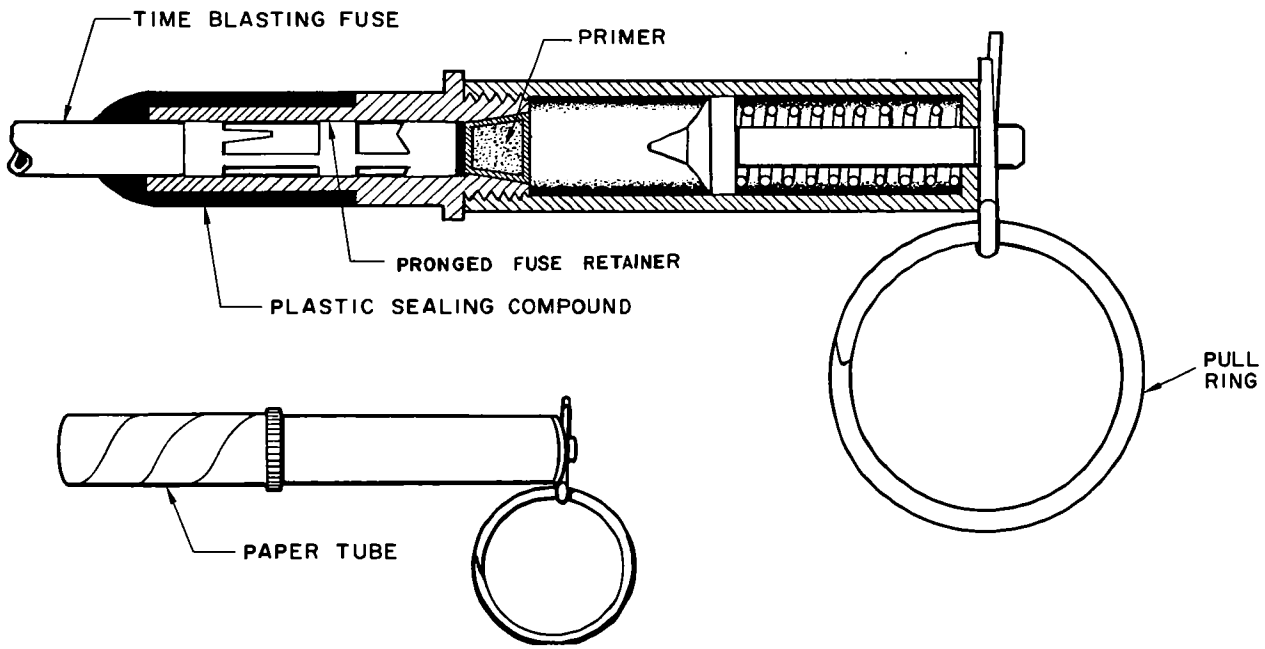



*Figure 1–46. M2 weatherproof fuse igniter.*

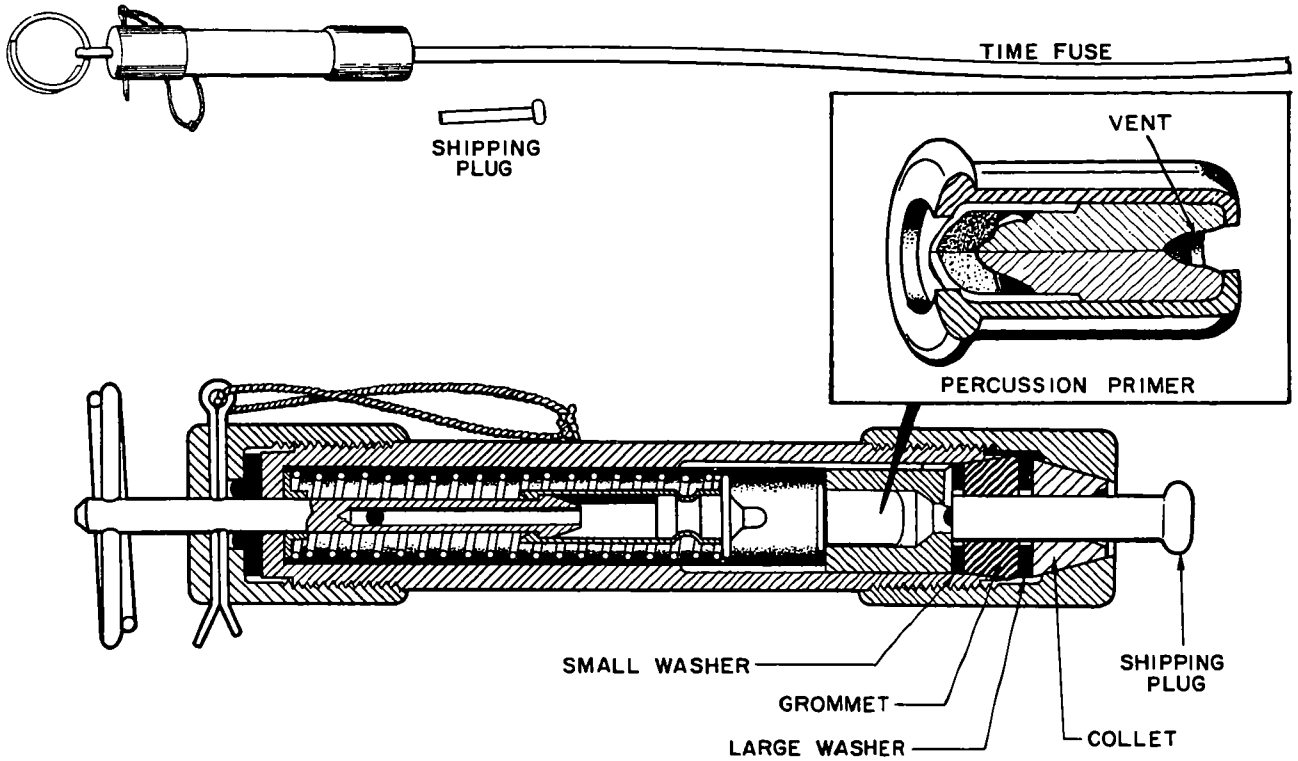



*Figure 1–47. M60 weatherproof fuse igniter.*

*Nonexplosive components*

| *Quantity* | *Item* |
|---|---|
| 60 | ADAPTER, PRIMING: M1A4 |
| 1 | CABLE, POWER, ELECTRICAL: firing, vinyl polymer insulation, two conductor, AWG No. 18 stranded, 500-ft coil |
| 50 | CLIP, CORD, DETONATING: M1 |
| 6 | INSULATION TAPE, ELECTRICAL: black adhesive, ¾-inch wide |
| 1 | COMPOUND: sealing, blasting cap, waterproof, ½-pint can |
| 1* | TAPE, PRESSURE-SENSITIVE ADHESIVE FILM: 2-inch wide, 72-yard long, roll. |
| 2 | TWINE: hemp, No. 18, 8-ounce ball |
| 2 | WIRE, ELECTRICAL: annunciator, waxed double cotton wrapped insulation, solid single conductor, AWG No. 20, 200-foot coil. |
| 50 | HOLDER, BLASTING CAP: M8 |

*Note.* Older demolition sets may contain two ½-pound cans of M1 adhesive paste instead of one roll of tape; either item is acceptable.

*Explosive components*

| *Quantity* | *Item* |
|---|---|
| 50 | CAP, BLASTING: electric M6 (or J–2) |
| 50 | CAP, BLASTING: nonelectric M7 (or J–1) |
| 80* | CHARGE, DEMOLITION: block, M112 1¼-lb. comp. C4 |
| 50 | CHARGE, DEMOLITION: block, 1-lb. TNT |
| 5 | CORD, DETONATING: fuse, primacord, 100-ft spool |
| 5 | DESTRUCTOR, EXPLOSIVE: universal, M10 |
| 2 | FUSE, BLASTING, TIME: M700, 50-foot coils |
| 50 | IGNITER, BLASTING FUSE: M60, weatherproof |
| 20* | CHARGE, DEMOLITION: M118, 2-lb |

*Note.* M5A1 block demolition charges, 2½-lb, comp. C4, may be used instead of M112 block demolition charges. Two M186 roll demolition charges may be used instesd of M118 demolition charges.

*b. Demolition Set, Explosive Initiating, Nonelectric.* The nonelectric demolition set consists of composition C4 demolition blocks and the demolition tools and accessories needed for nonelectric priming and firing (fig 1–50). The basic set consists of the items listed in (1) below.

(1) *Components issued as basic set.* These items may also be requisitioned separately for replacement purposes.

| *Quantity* | *Item* |
|---|---|
| 2 | BAG, CANVAS, CARRYING: demolition kit |
| 2 | BOX, CAP: ten-cap capacity, infantry |
| 2 | CRIMPER, CAP: M2 (w/fuse cutter) |
| 2 | KNIFE, POCKET |
| 2 | TAPE, COMPUTING: demolition charge |

(2) *Components issued separately.* The following items are required to complete the demolition set and should be on hand at all times. These items are not supplied with the set, and are to be requisitioned separately.

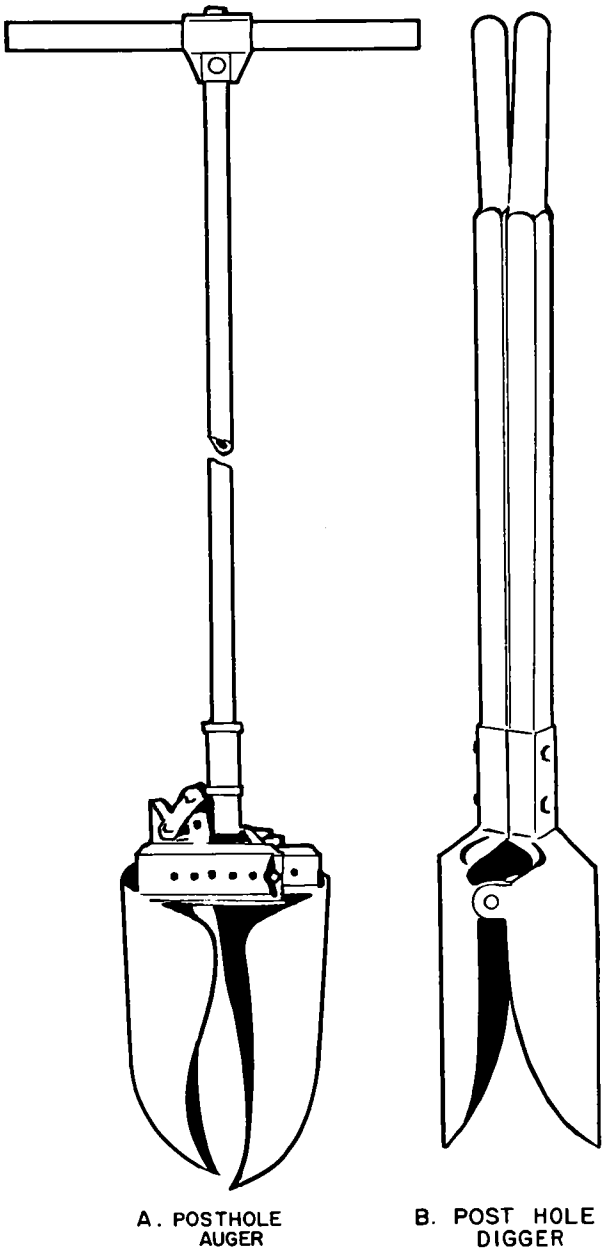



*Figure 1–48. Hand operated digging tools.*

*Nonexplosive components*

| *Quantity* | *Item* |
|---|---|
| 20 | ADAPTER, PRIMING: M1A4 |
| 50 | CLIP, CORD, DETONATING: M1 |
| 2 | INSULATION TAPE, ELECTRICAL: black adhesive, ¾-inch wide |
| 1 | COMPOUND: sealing, blasting cap, waterproof, ½-pint can |
| 1* | TAPE, PRESSURE-SENSITIVE ADHESIVE FILM: 2-inch wide, 72-yard roll |

*Note.* Older demolition sets may contain two ½-lb. cans of M1 adhesive paste instead of one roll of tape; either item is acceptable.

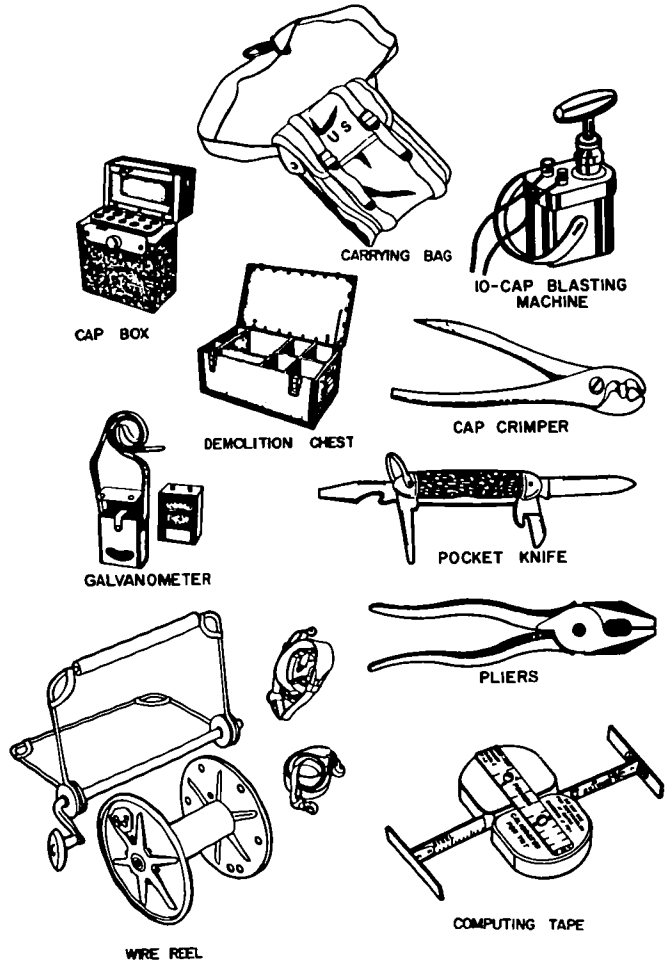



*Figure 1–49. Demolition set, electric initiating.*

*Explosive compononts*

| *Quantity* | *Item* |
|---|---|
| 50 | CAP, BLASTING: nonelectric, M7 (or J–1) |
| 80* | CHARGE, DEMOLITION: block, M112, 1½-lb comp. C4 |
| 2 | CORD, DETONATING: fuse, primacord, 100-ft spool |
| 2 | DESTRUCTOR, EXPLOSIVE: universal, M10 |
| 2 | FUSE, BLASTING, TIME: M700, 50-ft coils |
| 50 | IGNITER, BLASTING FUSE: M60, weatherproof |

*Note.* M5A1 block demolition charges, 2½-lb. comp. C4, may be used instead of M112 block demolition charges.

## 1–59. 165-mm Cartridge (HEP), M123E1

The combat engineer vehicle (CEV) mounts a 165-mm gun which fires a high explosive plastic, (HEP) cartridge. This cartridge contains approximately 60 pounds of composition A3, and is primarily used for breaching obstacles and destroying fortified positions. For further details of employment see FM 5–1 and TC 17–14.

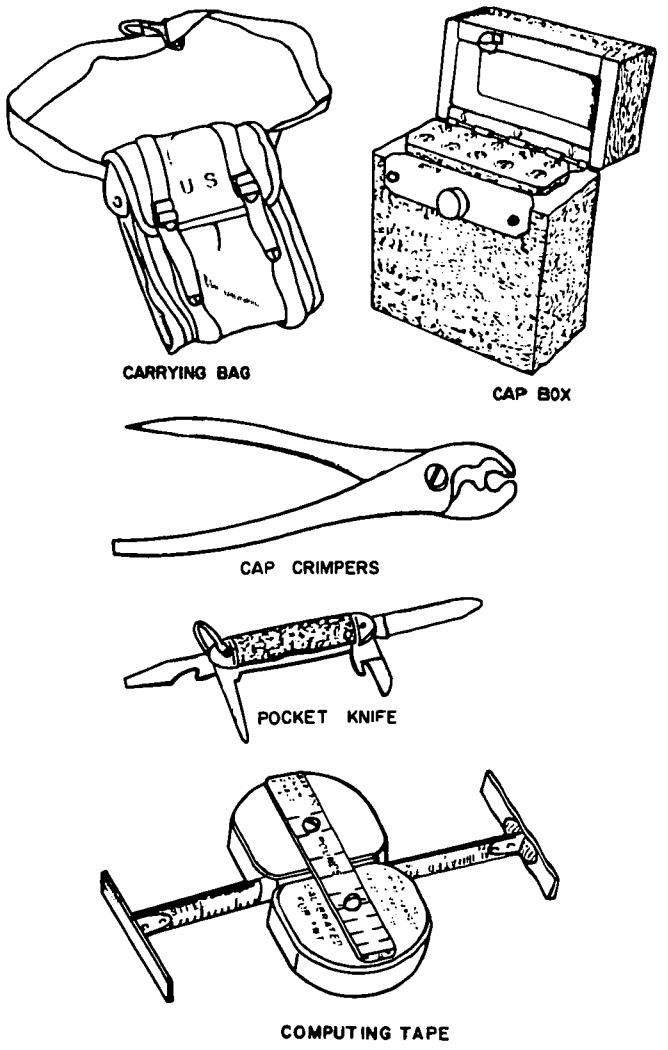



*Figure 1–50. Demolition set, nonelectric initiating.*

# CHAPTER 2

# FIRING SYSTEMS

## Section I. NONELECTRIC FIRING SYSTEMS

### 2–1. Introduction

Two types of systems for firing explosives are in general use—electric and nonelectric. Both have their individual priming methods and materials. In addition, detonating cord may be used with both systems to make them more efficient and effective, as described in paragraphs 2–10 through 2–16.

### 2–2. System Components and Assembly for Detonation

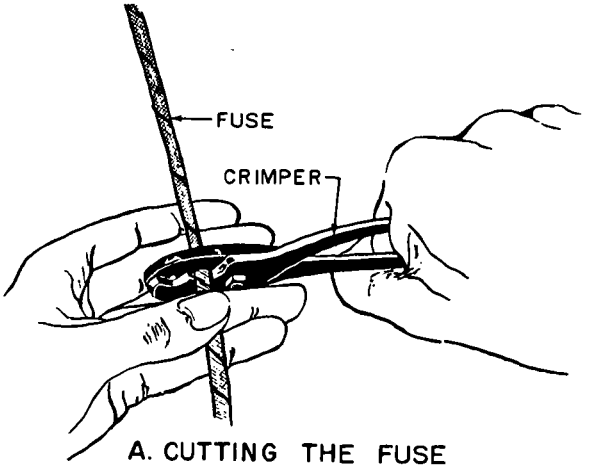
A nonelectric system is one in which an explosive charge is prepared for detonation by means of a nonelectric blasting cap. The basic priming materials consist of a nonelectric blasting cap, which provides the shock adequate to detonate the explosive, and the time blasting fuse, which transmits the flame that fires the blasting cap. If more than one charge must be detonated simultaneously, the nonelectric system must be combined with detonating cord (para 2–10—2–12) to insure simultaneous firing. The assembly of a basic nonelectric system follows.

*a.* Cut and discard a 6-inch length from the free end of the time blasting fuse to prevent a misfire caused by the exposed powder absorbing moisture from the air (A, fig 2–1). Then cut off a three foot length of time blasting fuse to check the burning rate. Split the end of the fuse, insert a match head into the split, light the match with another match and note the time it takes for the fuse to burn. Then compute the burning rate per foot by dividing the time in seconds by the length in feet.

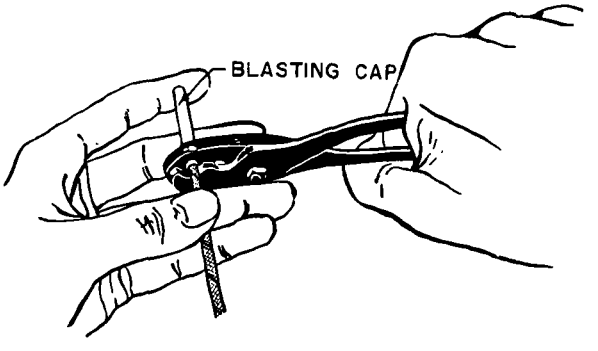
*b.* Cut the time blasting fuse long enough to permit the person detonating the charge to reach a safe distance by walking at a normal pace before the explosion. This cut should be made squarely across the time fuse.

*c.* Take one blasting cap from the cap box, inspect it by looking into the open end. If any foreign matter or dirt is present, hold it with the open end down, and shake it gently or bump the hand holding it against the other hand. *If foreign matter does not come out, discard cap. Never tap the cap with a hard object or against a hard object. Never blow into the cap. Do not insert anything into the cap to remove any dirt or foreign material.*

*d.* Hold the time blasting fuse vertically with the square cut end up and *slip the blasting cap gently down over it so that the flash charge in*




A. CUTTING THE FUSE




B. CRIMPING ON THE CAP

*Figure 2–1. Cutting and capping the fuse.*

*the cap is in contact with the end of the time fuse; if not in contact, it may misfire. Never force the time fuse into the blasting cap by twisting or any other method.* If the end is flattened or it is too large to enter the blasting cap freely, roll it between the thumb and fingers until the size is reduced to permit free entry.

*e.* After the blasting cap has been seated, grasp the time blasting fuse between the thumb and third finger of the left hand and extend the forefinger over the end of the cap to hold it firmly against the end of the time fuse. Keep a slight pressure on the closed end of the cap with the forefinger (B, fig 2–1).

*f.* Slide the second finger down the outer edge of the blasting cap to guide the crimpers (B, fig 2–1), and thus obtain accurate crimping, even in darkness.

*g.* Crimp the blasting cap at a point 1/8 to 1/4 of an inch from the open end. *A crimp too near the explosive in the blasting cap may cause detonation. Point the cap out and away from the body during crimping* (fig 2–2).

*Note.* If the blasting cap should remain in place several days before firing, protect the joint between the cap the time blasting fuse with a coating of sealing compound or some similar substance. (*As this sealing compound (para 1–50), a standard issue, does not make a waterproof seal, submerged charges should be fired immediately.*)

*h.* Pass the end of the time blasting fuse through the priming adapter. (The time fuse should move through the adapter easily.) Then pull the cap into the adapter until it stops, insert into the cap well of the explosive, and screw the adapter into place. If no priming adapter is available, insert the blasting cap into the cap well and tie it in place with a string or fasten it with adhesive tape or some other available material. (For details of nonelectric priming of demolition blocks, see para 2–18).

*Note.* For long lengths of time blasting fuse it may be more convenient to pass the end of the fuse through the priming adapter before crimping the cap onto the time fuse.

*i.* Attach M60 weatherproof fuse igniter (para 1–57*n*) as follows:

(1) Unscrew the fuse holder cap two or three turns but do not remove. Press the shipping plug into the igniter to release the split collet (fig 1–47), and rotate the plug as it is removed.

(2) Insert the free end of the time fuse in place of the plug until it rests against the primer.

*Figure 2–2. Proper position for crimping the blasting cap.*

(3) Tighten the cap sufficiently to hold the fuse in place and thus weatherproof the joint.

(4) To fire, remove the safety pin, hold the barrel in one hand, and pull on the pull ring with the other, taking up the slack before making the final strong pull. In the event of a misfire, the M60 can be reset quickly without disassembly by pushing the plunger all the way in and attempting to fire as before. (It cannot be reset underwater however, because water can enter the interior of the nylon case through the holes in the pull rod. The fuse igniter is reusable if the primer is replaced.)

*Note.* The M2 weatherproof fuse igniter (fig. 1–46) may be attached by sliding the fuse retainer over the end of the fuse, firmly seating it, and applying sealing compound at the joint between the time blasting fuse and the igniter to protect the open end of the fuse from moisture. In firing, hold the barrel in one hand and pull on the pull ring with the other.

*j.* If a fuse igniter is not available, light the time blasting fuse with a match by splitting the fuse at the end (fig 2–3), placing the head of an unlighted match in the powder train, and then light the inserted match head with a flaming match or by rubbing the abrasive on the match box against it.

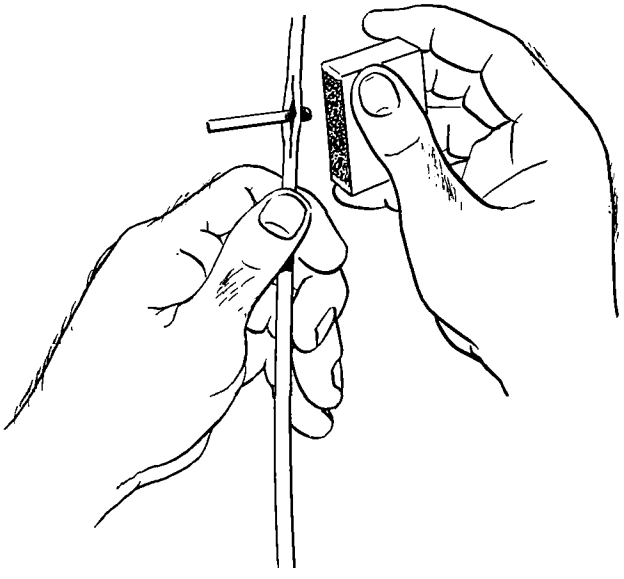


*Figure 2–3. Lighting time blasting fuse with match.*

## 2–3. Nonelectric Misfires

*a. Prevention.* Working on or near a misfire is the most hazardous of all blasting operations. A misfire should be extremely rare if these procedures are followed closely:

(1) Prepare all primers properly.

(2) Load charges carefully.

(3) Place primer properly.

(4) Perform any tamping operation with care to avoid damage to an otherwise carefully prepare charge.

(5) Fire the charge according to the proper technique.

(6) If possible, use dual firing systems (para 2–13—2–16). If both systems are properly assembled, the possibility of a misfire is reduced to a minimum.

(7) Do not use blasting caps underground; use detonating cord.

*b. The Clearing of Nonelectric Misfires.* Occasionally, despite all painstaking efforts, a nonelectric misfire will occur. Investigation and correction should be undertaken only by the man that placed the charge. For a charge primed with a nonelectric cap and time blasting fuse, the procedure is as follows:

(1) Delay the investigation of the misfire at least 30 minutes after the expected time of detonation. This should be ample time for any delayed explosion to take place because of a defective powder train in the fuse. Under certain combat conditions, however, immediate investigation may be necessary.

(2) If the misfired charge is not tamped, lay a primed one-pound charge at the side of the charge, without moving or disturbing it, and fire.

(3) If the misfired charge has no more than a foot of tamping, attempt to explode it by detonating a new 2-pound charge placed on top.

(4) If the misfired charge is located in a tamped borehole, or if the tamped charge is so situated as to make method (3) above impractical, carefully remove the tamping by means of wooden or nonmetallic tools. Avoid accidentally digging into the charge. Also, the tamping may be blown out by means of a stream of compressed air or water if either is available. Constant checking of the depth of the borehole from the ground surface to the top of the charge during digging will minimize the danger of striking the charge. When the charge has been uncovered within 1 foot, insert and detonate a new 2-pound primer. Whenever possible, detonating cord should be used to prime underground charges and the blasting cap located above ground (see para 2–10—2–12).

(5) An alternate method of reaching a deep misfire charge is to drill a new hole within one foot of the old one and to the same depth. A 2-pound primed charge is then placed in the new hole to detonate the misfired charge. Extreme care is required in drilling the new hole to avoid striking the old misfired charge or placing the new charge too far away to induce detonation.

## Section II. ELECTRIC FIRING SYSTEMS

### 2–4. Components and Assembly for Detonation

An electric firing system is one in which electricity is used to fire the primary initiating element. An electric impulse supplied from a power source, usually an electric blasting machine, travels through the firing wire and cap lead wires to fire an electric blasting cap. The chief components of the system are the electric blasting cap, firing wire, and the blasting machine. Detailed information about electric blasting equipment is contained in TM 9–1375–203–15. The preparation of the explosive charge for detonation by electric means is called electric priming. The proper methods and sequence of operations of electric priming are described below.

*a. Place Charges.* Prepare and place all explosive charges as prescribed by the methods in chapter 3. (Details of preparing demolition blocks for electric priming are given in para 2–18.)

*b. Lay Out Firing Wire.*

(1) After locating a firing position a safe distance away from the charges, lay out the firing wire from the charges to the firing position.

(2) Test the firing wire as described in paragraph 2–7.

(3) Twist the free ends of the firing wire together to prevent an electric charge from building up in the firing wire.

*c. Test Blasting Caps.*

(1) Test each blasting cap to be used in the electric firing system as described in paragraph 2–7.

(2) After each cap has been tested, twist the free ends of the cap lead wires together or shunt them with the short circuit shunt provided to prevent an electric charge from building up in the cap lead wires.

*d. Connect Series Circuit.*

(1) If two or more electric blasting caps are used, connect their lead wires into one of the two series circuits described in paragraph 2–6.

(2) If more than *10* blasting caps are used in the series circuit, or if the circuit is complicated, it should be tested with the test set or galvanometer (para 2–7).

(3) Splice the free cap lead wires to the firing wire.

*e. Insert Caps Into Charges.* Place the blasting caps into the explosive charges and fasten the caps securely to the charges (fig 2–4). (For details of electric priming of demolition blocks see para 2–18).

*f. Test Entire Circuit.*

(1) Move to the firing position and test the entire firing circuit with the test set or galvanometer as described in paragraph 2–7.

(2) Twist the free ends of the firing wire together.

*g. Test Blasting Machine.* Test operate the blasting machine several times as outlined in TM 9–1375–203–15 to insure that it operates properly.

*h. Connect Blasting Machine.*

(1) Untwist the free ends of the firing wire and fasten them to the two posts of the blasting machine.

(2) Operate the blasting machine to fire the charges.

*i. Precautions.*

(1) *Two or more caps.* If two or more electric blasting caps are connected in the same circuit, be sure that they are of the same type and made by the same manufacturer. This is essential to prevent misfires, as blasting caps of different manufacturers have different electrical characteristics which can result in some caps in the circuit not firing because others fire more quickly and thus break the circuit before the slower caps have received enough electricity to fire. This is not true, however, of the M6 special electric blasting caps—all of which are made according to the same specifications. Blasting caps of the same manufacturer may be identified by the label, color of the cap, or shape of the shunt.

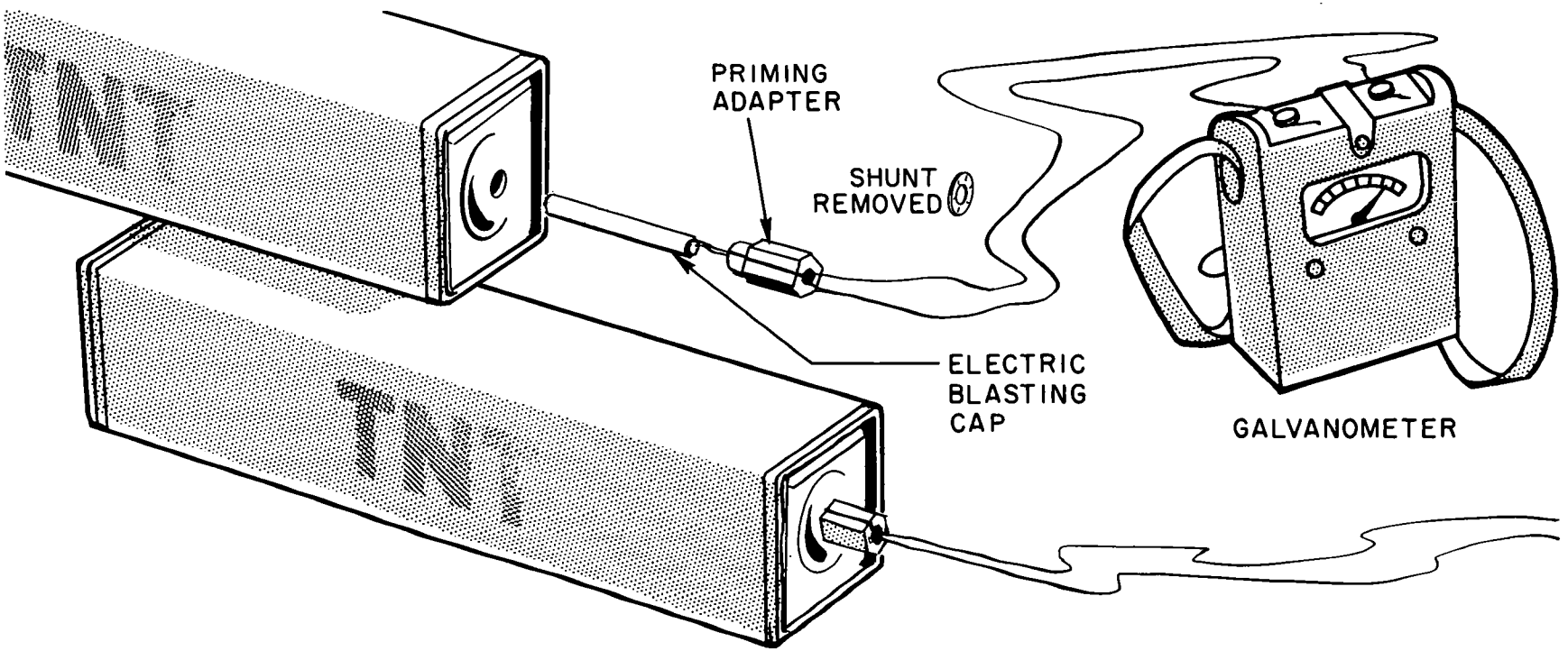



*Figure 2–4. Assembling the electric primer.*

(2) *Firing the circuit.* For safety reasons, only one individual should be detailed to connect the blasting machine to the firing circuit and to fire the circuit. He should be responsible for the care and security of the blasting machine at all times during blasting activities. He also should either connect the blasting wires in the circuit or check their connection by on-the-spot visual examination.

## 2–5. Splicing Electric Wires

Insulated wires, before splicing, must have the insulating material stripped from the ends. Expose about 3 inches of bare wire (fig 2–5), and remove any foreign matter such as enamel by carefully scraping the wire with the back of a knife blade or other suitable tools. The wires should not be nicked, cut, or weakened when the wires are bared, and multiple strand wires should be twisted lightly after scraping.

*a. Splicing Method.* Two wires, which have been prepared as described above, may be spliced as shown in figure 2–5. This is called the Western Union "pigtail" splice. Two pairs of wires are spliced in the same manner as the two wire splice above. One wire of one pair is spliced to one wire of the other pair, and the process is repeated for the other two wires.

*b. Precautions for Splicing.* A short circuit may occur very easily at a splice if certain precautions are not observed. If pairs of wires are spliced, stagger the two separate splices and tie with twine or tape as in (1), figure 2–6. An alternate method of preventing a short circuit at the point of splice is shown in (2), figure 2–6. The splices are separated, not staggered, in the alternate method. Whenever possible insulate splices from the ground or other conductors by wrapping them with friction tape or other electric insulating tape. This is particularly necessary when splices are placed under wet tamping. Circuit splices, not taped or insulated, should not lie on moist ground. The splices should be supported on rocks, blocks, or sticks so that only the insulated portions of the wires touch the ground. They may also be protected by inserting them into the cardboard cap spools which may be bent to hold the splice firmly inside. Splices may be protected from damage from pull by tying the ends in an overhand or square knot, allowing sufficient length for each splice ((1), fig 2–5).

## 2–6. Series Circuits

*a. Common Series.* This is used for connecting

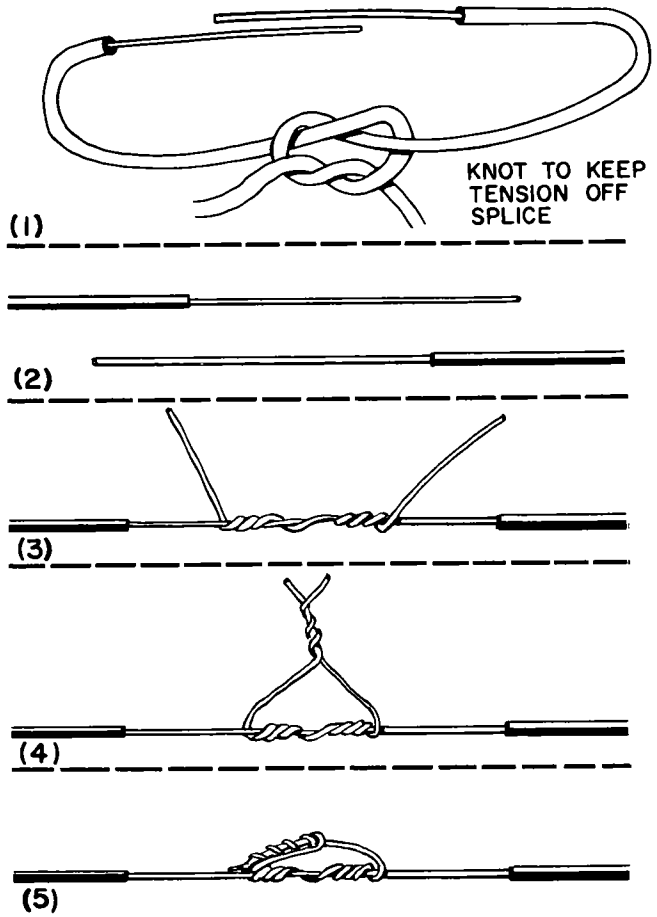



*Figure 2–5. Western Union "pigtail" splice.*

two or more charges fired electrically by a single blasting machine (A, fig 2–7). A common series circuit is prepared by connecting one blasting cap lead wire from the first charge to one lead wire in the second charge and so on until only two end wires are free, then connecting the free ends of the cap lead wires to the ends of the firing. Connecting wires (usually annunciator wire) are used when the distance between blast-

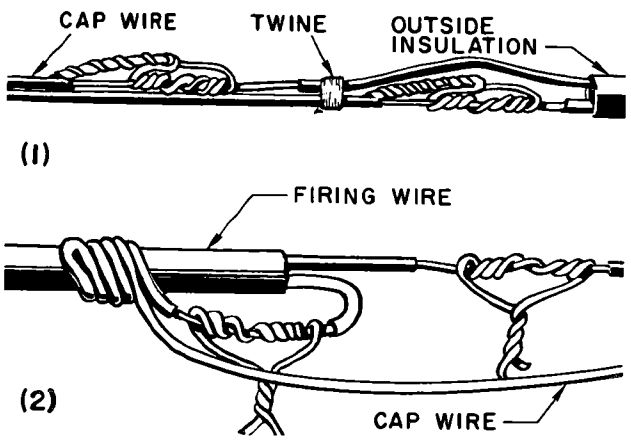



*Figure 2–6. Splicing two pairs of wires.*

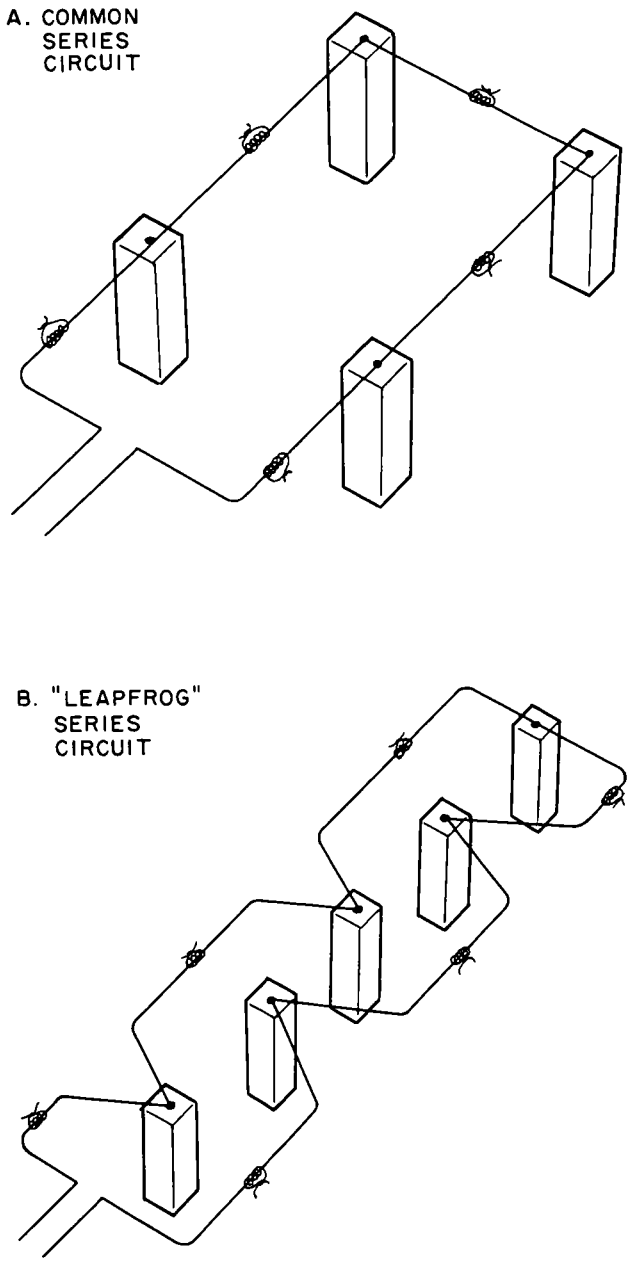



*Figure 2–7. Series circuits.*

ing caps is greater than the length of the usual cap lead wires.

*b. "Leapfrog" Series.* The "leapfrog" method of connecting caps in series (B, fig 2–7) is useful for firing ditching charges or any long line of charges. It consists of omitting alternate charges on the way and then connecting them to form a return path for the electric impulse to reach the other lead of the firing wire. This brings both end wires out at the same end of the line of charges, and thus eliminates laying a long return lead from the far end of the line of charges back to the firing wire.

## 2–7. Testing Electric Wires, Blasting Caps and Circuits

*a. Firing Wire May be Tested as Follows:*

(1) When using M51 blasting cap test set:

(*a*) Check test set by connecting the posts with a piece of bare wire (para 1–54) (fig 2–8). The indicator lamp should flash when the handle is squeezed.

(*b*) Separate the firing wire conductors at both ends, and connect those at one end to the test set binding posts. Actuate test set. The indicator lamp should not flash. If it does, the firing wire has a short circuit (fig 2–9).

(*c*) Twist the wires together at one end, and connect those at the other end to the test set posts. Actuate test set. The indicator lamp should flash. If it does not flash, the firing wire has a break.

(2) When using the blasting galvanometer:

(*a*) Check galvanometer by holding a piece of metal across its terminals (para 1–53, fig 2–8). If the battery is good, this should show a wide deflection of the needle, approximately 25 units (zero ohms).

(*b*) Separate the firing wire conductors at both ends, and touch those at one end to the galvanometer posts. The needle should not move. If it does, the firing wire has a short circuit (fig 2–9).

(*c*) Twist the wires together at one end and touch those at the other end to the galvanometer posts. This should cause a wide deflection of the needle (about 6½ ohms or 23 to 24 units for a 500-foot length). (See note at end of *d*(2), below.) No movement of the needle indicates a break; a slight movement indicates a point of high resistance which may be caused by a dirty wire, loose wire connections, or wires with several strands broken off at connections.

*Note.* Firing wire may be tested on the reel, *but should be tested again after unreeling, which may separate broken wires unnoticed when reeled.*

*b. Electric Blasting Caps May be Tested as Follows:*

(1) When using the M51 blasting cap test set:

(*a*) Check the test set as described above.

(*b*) Remove the short circuit shunt from the lead wires of the electric blasting cap.

(*c*) Attach one cap lead wire to one binding post and tie other cap lead wire to the other post, and squeeze the test set handle. If the indicator lamp flashes, the blasting cap is

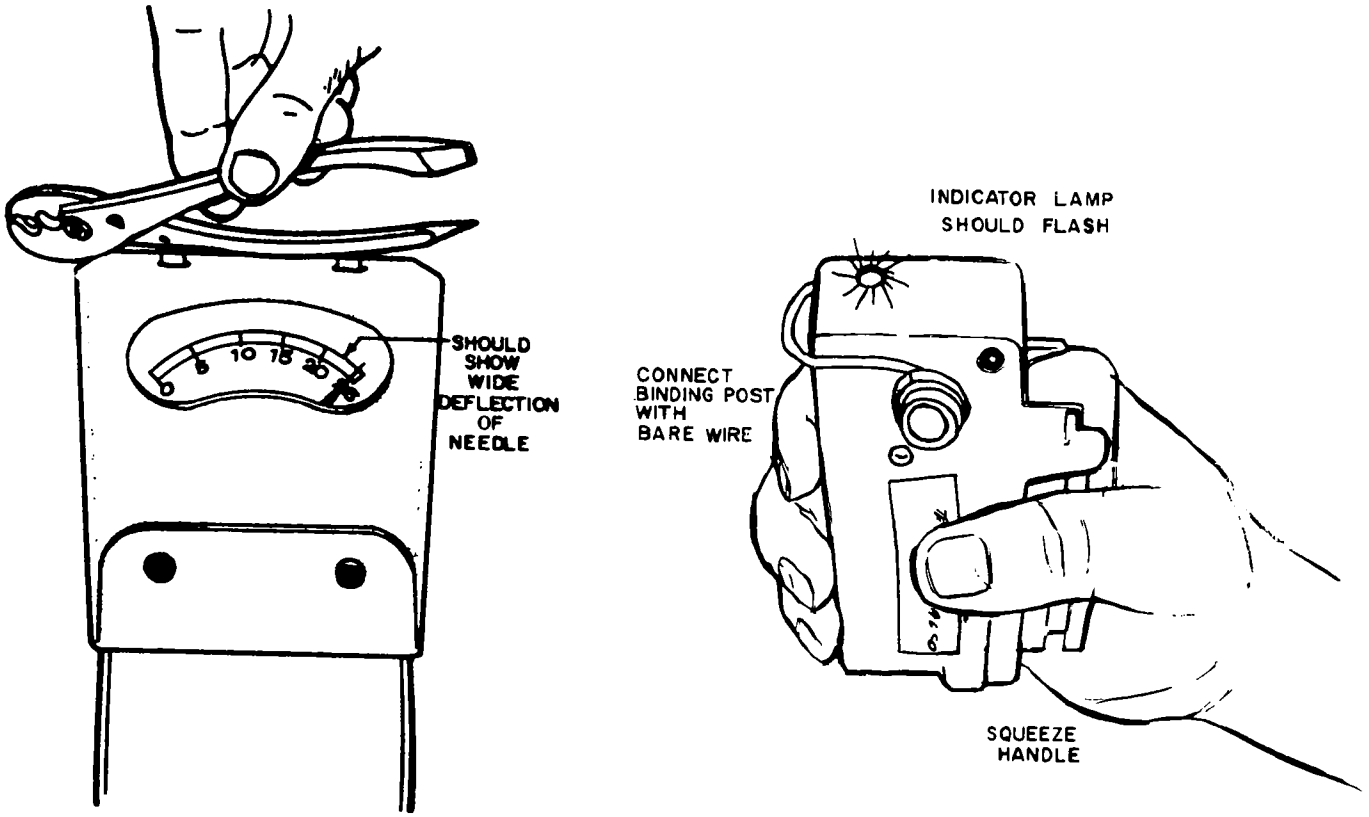



*Figure 2–8. Testing the galvanometer or test set.*

satisfactory. If it does not flash, the cap is defective and should not be used. During the test, *always point the explosive end of the blasting cap away from the body.*

(2) When using the blasting galvanometer:

(*a*) Check the galvanometer as described above.

(*b*) Remove the short circuit shunt.

(*c*) Touch one cap lead wire to one galvanometer post and the other cap lead wire to the other. If the galvanometer's needle deflects slightly less than it did when instrument was tested ((*a*) above) the blasting cap is satisfactory; if not, the cap is defective and should not be used. During the test, *always point the explosive end of the cap away from the body.*

*Note.* If the battery is fresh, the galvanometer should read 25 units (zero ohms) when the instrument is tested and about 24 units (about 2 ohms) when a good blasting cap is tested.

*c. Series Circuits May Be Tested as Follows:*

(1) Connect charges as shown in figure 2–8 (either method).

(2) When using the M51 blasting cap test set, connect the free ends of the blasting caps lead wires to the test set binding posts. The indicator lamp should flash.

(3) When using the blasting galvanometer, touch the free ends of the blasting cap lead wires to the galvanometer posts. This should cause a wide deflection of the needle.

*d. The Entire Circuit May be Tested as Follows:*

(1) Splice firing wires to series circuit and move to firing position.

(2) When using the blasting cap test set, connect the free ends of the firing wire to the binding posts. The indicator lamp should flash. If the lamp does not flash, the circuit is defective.

*Note. Since the M51 test set cannot discriminate between a firing circuit that is properly set up and one with a short in it, special care must be taken in wiring the circuit to avoid shorting.*

(3) When using the galvanometer touch the free ends of the firing wire to the galvanometer posts. This should cause a wide deflection of the needle. The magnitude of the deflection depends

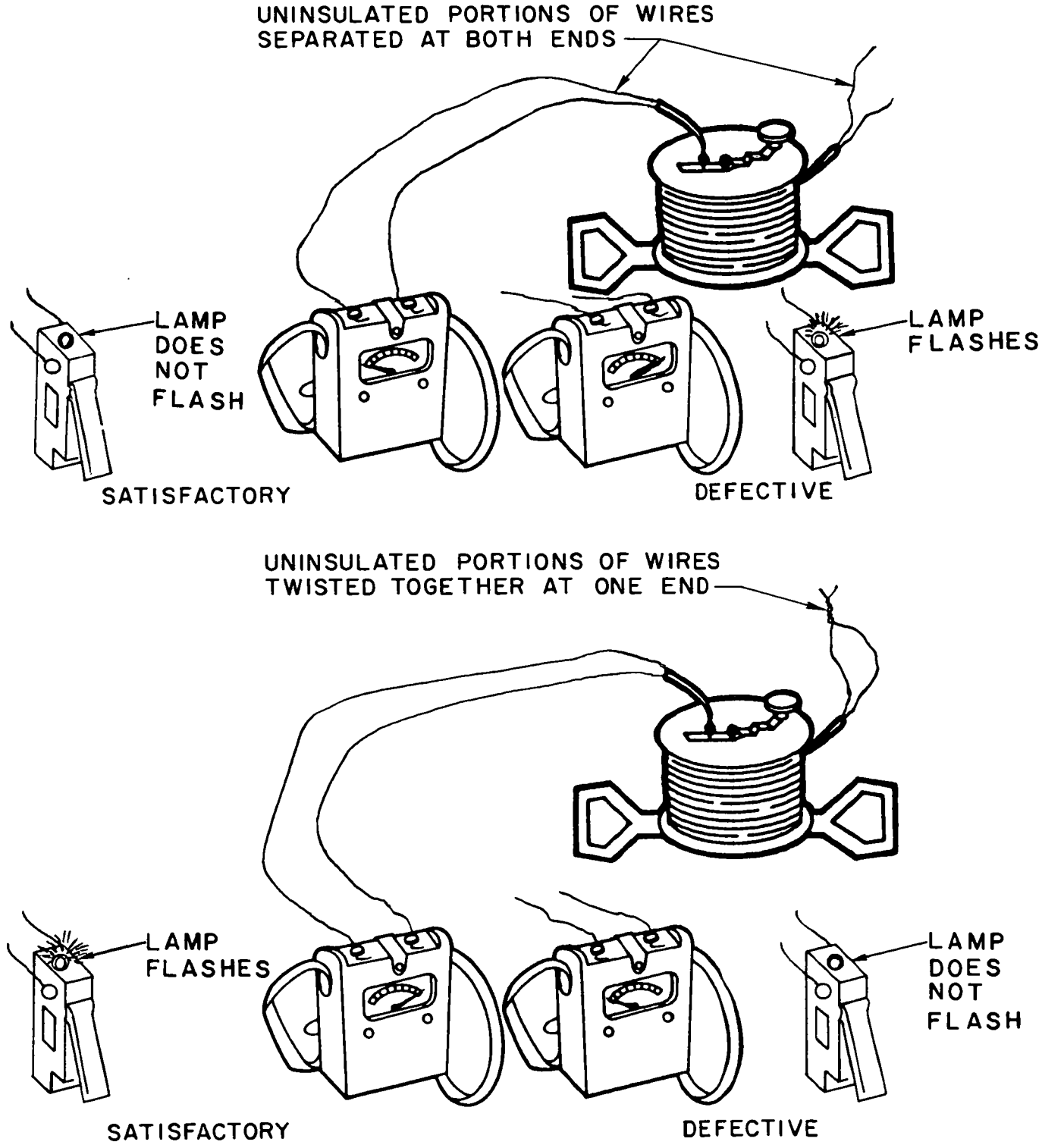



*Figure 2–9. Testing firing wire.*

upon the number of caps and the length of the firing wire. If there is no deflection, the circuit is defective. See appendix E for calculation of circuit resistance.

*Note. To get a "wide deflection of the needle" the galvanometer battery should be in good condition (para 1–53).*

(4) If the firing circuit is defective, shunt wires. Then go down range and recheck the circuit, repeating *a* and *b* above. If a splice is found

defective, resplice the wires. If a cap is found defective, replace it. Continue to test all caps and wires in the circuit, then test the entire circuit again to make sure that all breaks have been located before attempting to fire the charge.

## 2–8. Electric Misfires

*a. Prevention of Electric Misfires.* In order to prevent misfires, make one individual responsible for all electrical wiring in a demolition circuit. He should do all splicing to be sure that—

(1) All blasting caps are included in the firing circuit.

(2) All connections between blasting cap wires, connecting wires, and firing wires are properly made.

(3) Short circuits are avoided.

(4) Grounds are avoided.

(5) The number of blasting caps in any circuit does not exceed the rated capacity of the power source on hand.

*b. Cause of Electric Misfires.* Common specific causes of electric misfires include—

(1) Inoperative or weak blasting machine or power source.

(2) Improperly-operated blasting machine or power source.

(3) Defective and damaged connections, causing either a short circuit, a break in the circuit, or high resistance with resulting low current.

(4) Faulty blasting cap.

(5) The use in the *same circuit* of blasting caps (other than M6) made by different manufacturers.

(6) The use of more blasting caps than the power source rating permits.

*c. Clearing Electric Misfires.* Because of the hazards of burning charges and delayed explosions, electric misfires must be cleared with extreme caution. A burning charge may occur with the use of electric as well as nonelectric caps. Misfires of charges primed with detonating cord fired by electric blasting caps are cleared as described in paragraph 2–12. If the charge is dual-primed electrically and below ground, wait 30 minutes before investigating to make sure that the charge is not burning; or if dual-primed above ground, wait 30 minutes before investigating because a burning charge can set off the second cap causing the main charge to detonate. On the other hand, if the electric misfire is above ground and the charge is not dual-primed, investigate immediately. If the system is below ground and not dual-primed, proceed as follows—

(1) Check the firing wire connection to the blasting machine or power source terminals to be sure that the contacts are good.

(2) Make two or three more attempts to fire the circuits.

(3) Attempt to fire again, using another blasting machine or power source.

(4) Disconnect the blasting machine firing wire and wait 30 minutes before further investigation. Before moving on to the charge site, be sure that the firing wires at the power source end of the circuit are shunted to avoid any possible static electric detonation.

(5) Check the entire circuit, including the firing wire, for breaks and short circuits.

(6) If the fault is not above ground, remove the tamping material very carefully from the borehole to avoid striking the electric blasting cap.

(7) Make no attempt to remove either the primer or the charge.

(8) If the fault is not located by the removal of the tamping material to within 1 foot of the charge, place a new electric primer and 2 pounds of explosive at this point.

(9) Disconnect the blasting cap wires of the original primer from the circuit, and short the cap's lead wires.

(10) Connect the wires of the new primer in their place.

(11) Replace the tamping material.

(12) Initiate detonation. Detonation of the new primer will fire the original charge.

*Note.* In some cases it may be more desirable or expedient to drill a new hole within a foot of the old one at the same depth to avoid accidental detonation of the old charge and then place and prime a new 2-pound charge.

## 2–9. Premature Detonation by Induced Currents and Lightning

*a. Induced Currents.* The premature detonation of electric blasting caps by induced current from radio frequency signals is possible. Table 2–1 showing the minimum safe distance in respect to transmitter power, indicates the distance beyond which it is safe to conduct electrical blasting even under the most adverse conditions. This table applies to operating radio, radar and

television transmitting equipment. Mobile type transmitters and portable transmitters are prohibited within 50 meters of any electric blasting caps or electrical firing system. If blasting distances are less than those shown in table 2–1, the only safe procedure is to use a nonelectric system, which cannot be prematurely detonated by RF currents. If, however, the use of the electric system is necessary, follow precautions given in TM 9–1300–206. See also AR 385–63.

***Caution.*** **If electric blasting caps are to be transported near operating transmitters or in vehicles (including helicopters) in which a transmitter is to be operated, the caps will be placed in a metal can, the cover of which must be snug fitting and lap over the body of the can to a minimum depth of one-half inch. Caps will not be removed from container in proximity to operating transmitter unless the hazard has been evaluated and estimated to be acceptable.**

*b. Lightning.* Lightning is a hazard to both electric and nonelectric blasting charges. A strike or a nearby miss is almost certain to initiate either type of system. Lightning strikes, even at remote locations, may cause extremely high local earth currents and shock waves that may initiate electrical firing circuits. The effects of remote lightning strikes are multiplied by proximity to conducting elements, such as those found in buildings, fences, railroads, bridges, streams, and underground cables or conduct. Thus, the only safe procedure is to suspend all blasting activities during electrical storms and when one is impending.

*Table 2–1. Minimum Safe Distance from Transmitter Antennas*

| Average or peak transmitter power watts) (see note) | Minimum distance to transmitter (meters) |
|---|---|
| 0–30 | 30 |
| 30–50 | 50 |
| 50–100 | 110 |
| 100–250 | 160 |
| 250–500 | 230 |
| 500–1,000 | 305 |
| 1,000–3,000 | 480 |
| 3,000–5,000 | 610 |
| 5,000–20,000 | 915 |
| 20,000–50,000 | 1,530 |
| 50,000–100,000 | 3,050 |

*Note.* When the transmission is a pulsed or pulsed continuous wave type and its pulae width is leas than 10 microaeconds, the left hand column indicates average power. For all other transmissions, including those with pulse widths greater than 10 microseconds, the left hand column indicates peak power.

*c. Electric Power Lines.* Electric firing should not be performed within 155 meters of energized power transmission lines. When it is necessary to conduct blasting operations at distances closer than 155 meters to electric power lines, nonelectric firing systems should be under or the power lines deenergized (AR 385–63).

## Section III. DETONATING CORD FIRING SYSTEMS

### 2–10. Methods of Use

Of all the firing systems for explosives, a detonating cord firing system is probably the most versatile and in many cases the most easily installed. It is especially applicable for underwater and underground blasting because the blasting cap of the initiating system may remain above the water or ground.

*a.* An electric system consisting of an electric blasting cap, initiated by a blasting machine or other power source, or a nonelectric blasting cap initiated by a fuse igniter and a length of time blasting fuse, is used to initiate detonating cord.

*b.* The blasting cap, electric or nonelectric, is attached to a point 6 inches from the free end of the detonating cord by numerous wraps of string, wire, cloth, or tape.

### 2–11. Detonating Cord Connections

A detonating cord clip (fig 1–33) or square knot pulled tight is used to splice the ends of detonating cord. At least a 6-inch length should be left free at both sides of the knot (fig 2–10). When fabric is used to cover the detonating cord, the fabric must not be removed. The knot may be placed in water or in the ground but the cord must be detonated from a dry end.

*a. Branch Line Connections.* A branch line is fastened to a main line by means of a clip (fig 1–33) or a girth hitch with one extra turn (fig 2–11). The angle formed by the branch line and the cap end of the main line should not be less than 90° from the direction from which the blast is coming; at a smaller angle, the branch line may be blown off the main line without being detonated. At least 6 inches of the running end of the branch line is left free beyond the tie.

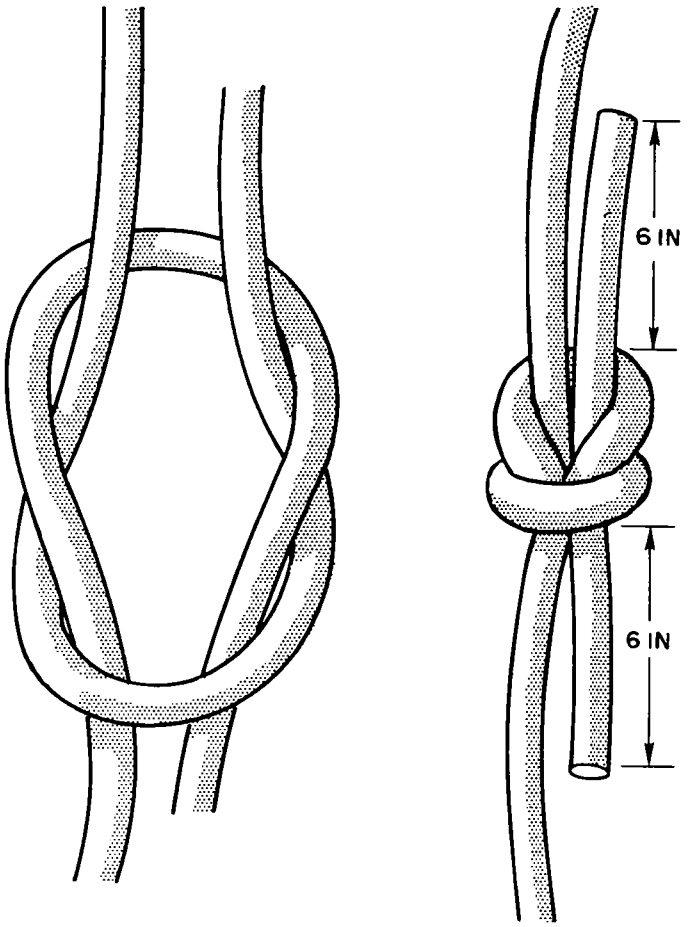



*Figure 2–10. Square knot connections.*

*b. Ring Main.* A ring main is made by bringing the main line back in the form of a loop and attaching it to itself with a girth hitch with one extra turn (fig 2–12). This will detonate an almost unlimited number of charges. The ring main makes the detonation of all charges more positive because the detonating wave approaches the branch lines from both directions and the charges will be detonated even when there is one break in the ring main. Branch line connections should be made perpendicular to the ring main. Kinks in lines should be avoided, and curves and angles should not be sharp. Any number of branch lines may be connected to the ring main, but a branch line is never connected at a point where the ring main is spliced. In making detonating cord branch line connections, avoid crossing lines. However, if this is necessary, be sure to have at least one foot of clearance at all points between the detonating cords; otherwise, the cords will cut each other and destroy the firing system.

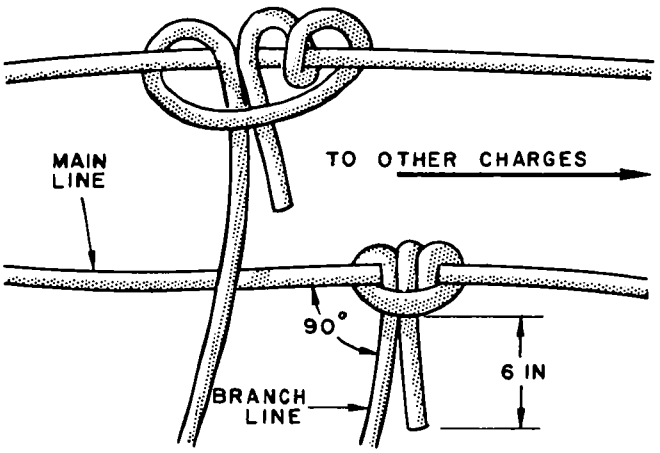



*Figure 2–11. Girth hitch with one extra turn.*

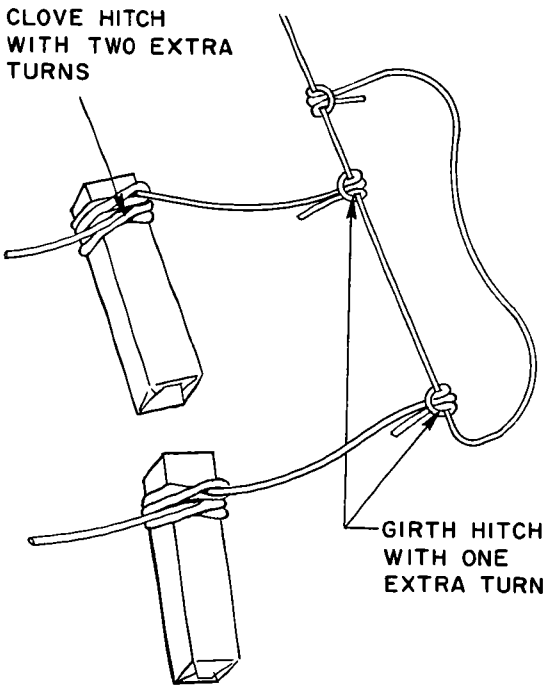



*Figure 2–12. Ring main with branch lines.*

## 2–12. Detonating Cord Misfires

*a. Failure of Nonelectric Blasting Cap.* If a nonelectric blasting cap attached to detonating cord fails to function, delay the investigation for at least 30 minutes. Then cut the detonating cord main line between the blasting cap and the charge, and fasten a new blasting cap on the detonating cord.

*b. Failure of Electric Blasting Cap.* If an exposed electric blasting cap fastened to detonating cord fails to fire, disconnect the blasting

machine immediately and investigate. Test the blasting circuit for any breaks or short circuit. Short the firing wire leads before leaving firing position to correct the problem. If necessary, replace the original blasting cap.

*c. Failure of Detonating Cord.* If detonating cord fails to function at the explosion of an exposed electric or nonelectric blasting cap, investigate immediately. Attach a new blasting cap to the detonating cord, taking care to fasten it properly.

*d. Failure of Branch Line.* If the detonating cord main line detonates but a branch line fails, fasten a blasting cap to the branch line and fire it separately.

*e. Failure of Charge to Explode.* If the charge is above ground, and the detonating cord leading to a charge detonates but the charge fails to explode, delay investigation until it is certain that the charge is not burning. If the charge is in the ground, wait 30 minutes. If the charge is intact, insert a new primer. If the charge is scattered by the detonation of the original detonating cord, reassemble as much of the original charge as possible, place a new charge if necessary, and reprime. Make every attempt possible to recover all explosives scattered by misfire, particularly those used in training exercises.

## Section IV. DUAL FIRING SYSTEMS

### 2–13. Introduction

There is always a certain amount of danger to personnel investigating misfires. Since dual priming increases greatly the probability of successful, firing, it should be used whenever possible. Dual priming consists of two complete systems independent of each other, and each capable of firing the same charge. It can be two electric systems, two nonelectric systems, or an electric and nonelectric system.

### 2–14. Nonelectric Dual Firing System

This consists of two independent nonelectric systems for firing a single charge or set of charges. If two or more charges are to be fired simultaneously, two detonating cord ring mains are laid out, and a branch line from each charge is tied into each ring main. Figure 2–13 shows the layout for a nonelectric dual firing system.

### 2–15. Electric Dual Firing System

This dual firing system consists of two independent electric circuits, each with an electric blasting cap in each charge, so that the firing of either circuit will detonate all charges. The correct layout is shown in figure 2–14. The firing wires of the two circuits should be kept separated so that both will not be cut by a single bullet or a single shell fragment. The firing points also should be at two separate locations.

### 2–16. Combination Dual Firing System

The combination dual firing system uses an electric and nonelectric firing system (fig 2–15). Each charge is primed electrically and nonelectrically. Both the electric and nonelectric systems must be entirely independent of each other. The nonelectric system must be fired first.

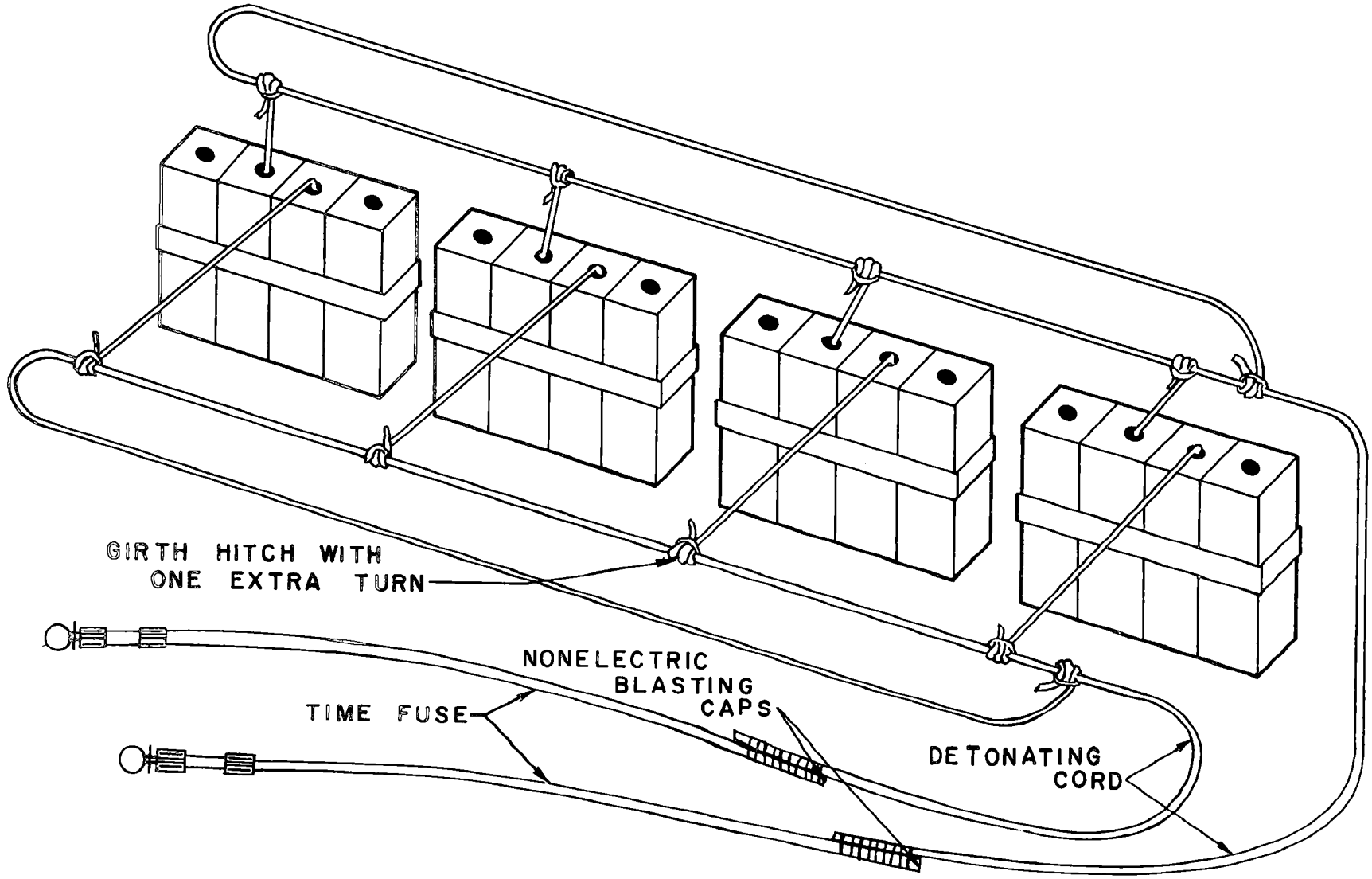



*Figure 2-13. Nonelectric dual priming.*

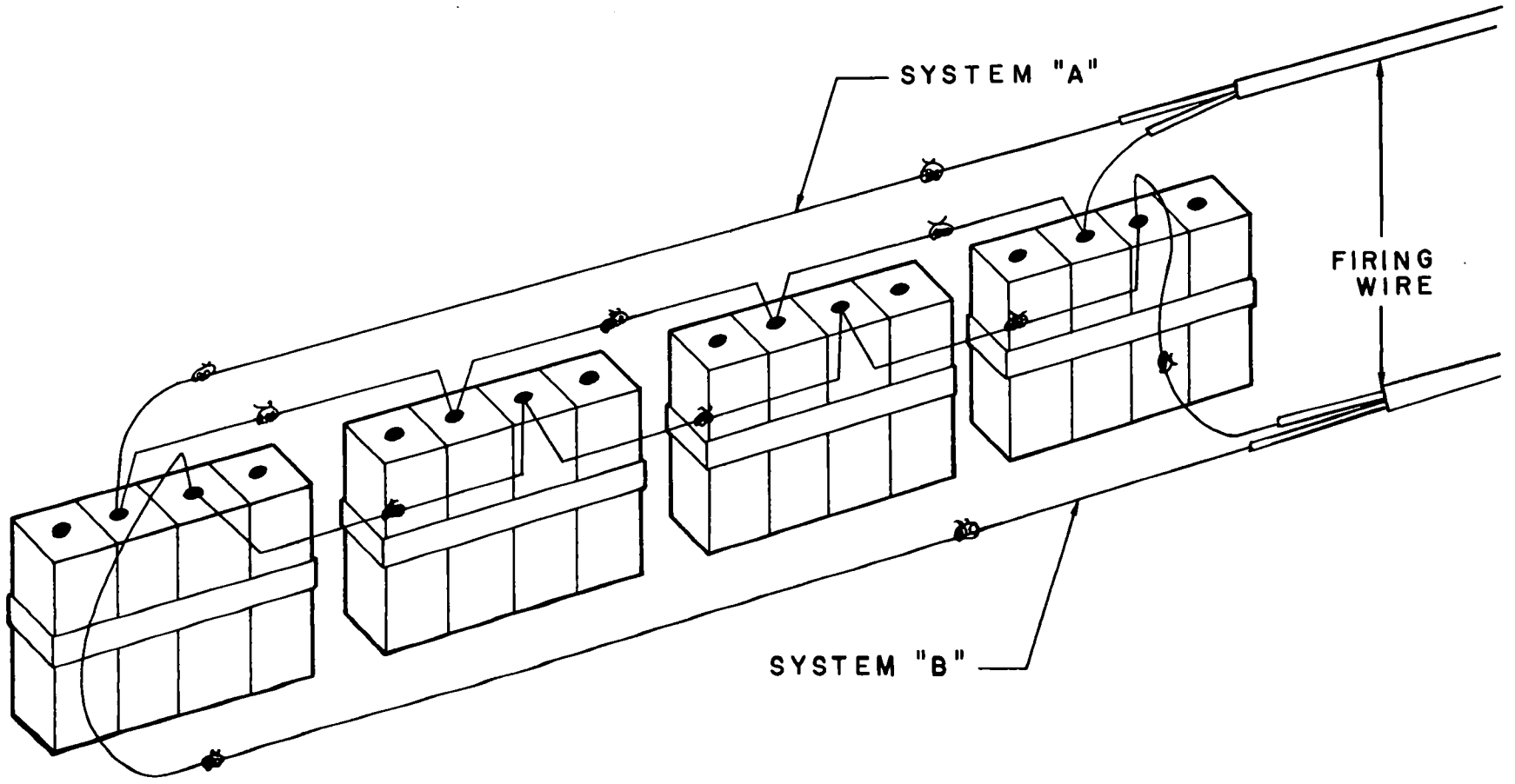



*Figure 2–14. Electric dual firing system.*

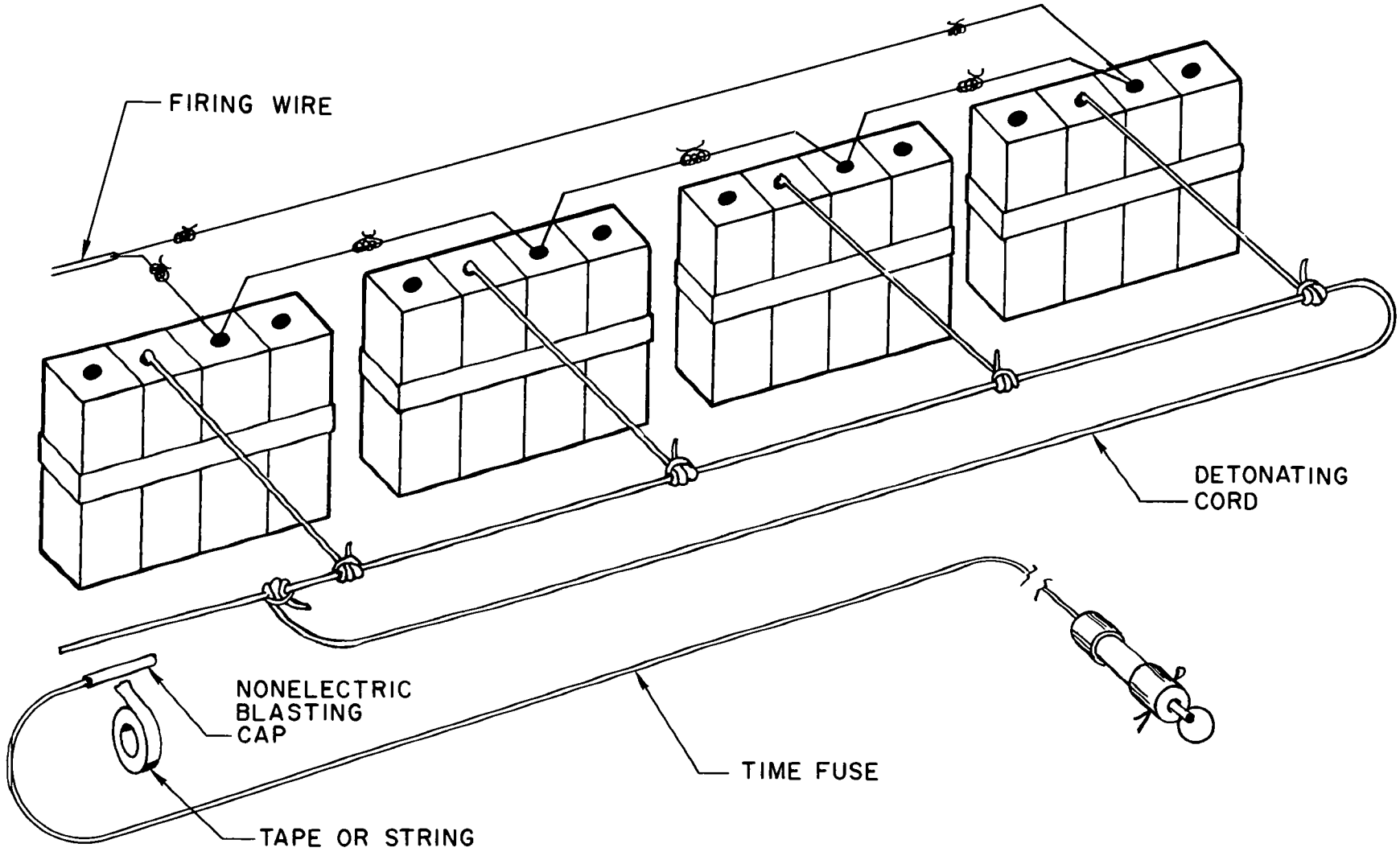



*Figure 2–15. Combination dual firing system.*

## Section V. PRIMING CHARGES

### 2–17. Introduction

This section will show nonelectric, electric, and detonating cord methods of priming most basic explosives. Certain terminology should be clarified since it will appear frequently in this section.

*a. Nonelectric Firing System.* A nonelectric firing system consists of a fuse igniter, a length of time blasting fuse, and a nonelectric blasting cap. (A, fig 2–16).

*b. Electric Firing System.* An electric firing system consists of a blasting machine or some other means of producing current, the necessary number of reels of firing wire, and electric blasting cap(s) (B, fig 2–16).

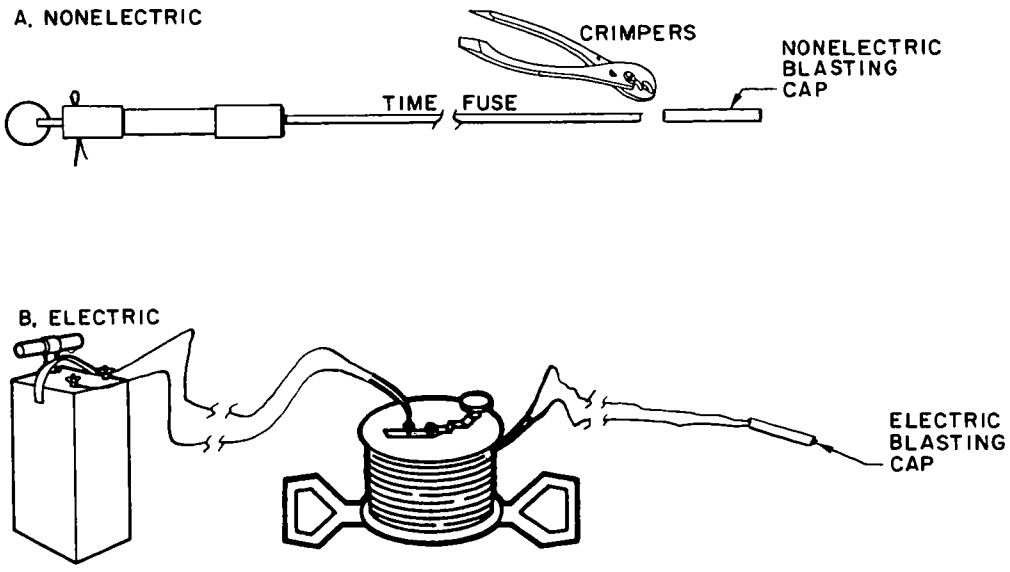



*Figure 2–16. Initiation systems.*

*c. Detonating Cord.* Detonating cord can be used to fire several charges simultaneously. Charges in several locations can be detonated by a single blasting cap when detonating cord ring mains are used and the charges are primed with detonating cord (para 2–10—2–12).

### 2–18. Priming Demolition Blocks

*a. Nonelectric Priming.* Demolition blocks may or may not have threaded cap wells. Priming adapters should be used, if available, to secure the nonelectric blasting cap and time blasting fuse to demolition blocks with threaded cap wells (fig 2–17, para 1–45 and 2–2).

(1) If priming adapters are not available but the blocks have threaded cap wells, they are primed as follows: (method 1, fig 2–18)

(*a*) Wrap a string tightly around the block and tie it securely leaving about 6 inches of loose string on each end after making the tie.

(*b*) Insert a blasting cap with fuse attached into the cap well.

(*c*) Tie the loose string around the fuse to prevent the blasting cap from being separated from the block.

*Note.* Do not tie string so tight that powder train is broken in the fuse.

(2) If the demolition block does not have a cap well, proceed as follows:

(*a*) Make a hole in the end of the block with a pointed nonsparking instrument or the pointed handle on the M2 crimpers large enough to contain the blasting cap (method 2, fig 2–18).

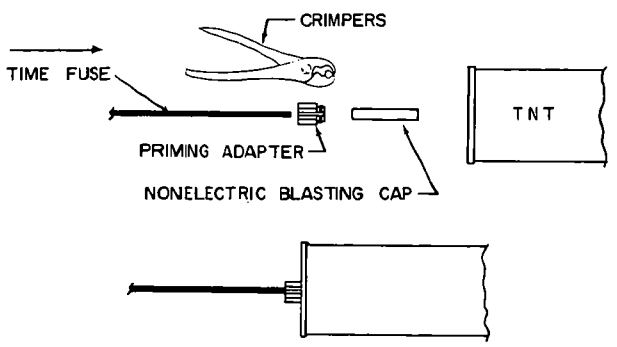



*Figure 2–17. Nonelectric priming with priming adapter.*

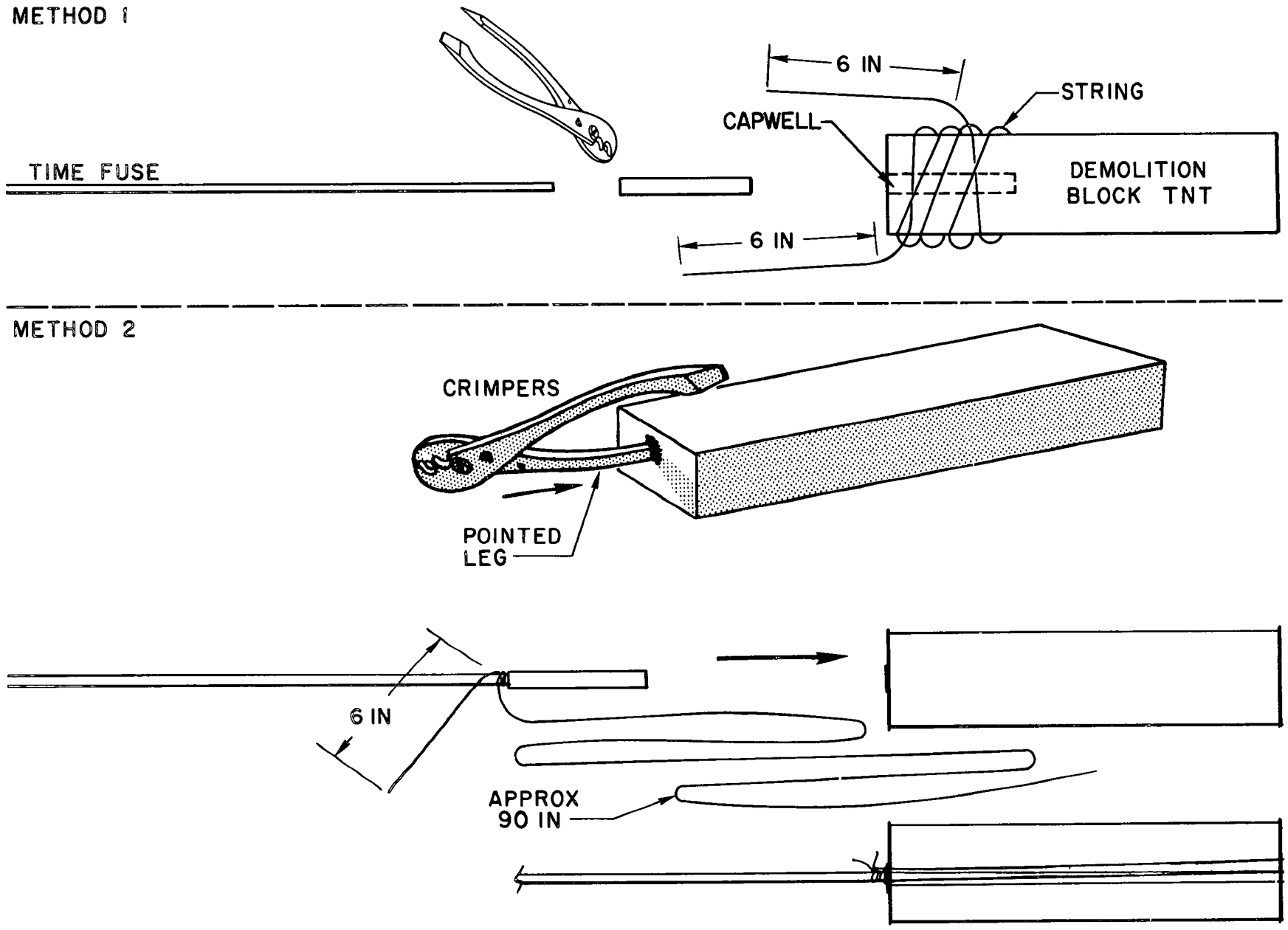



*Figure 2–18. Nonelectric priming without priming adapter.*

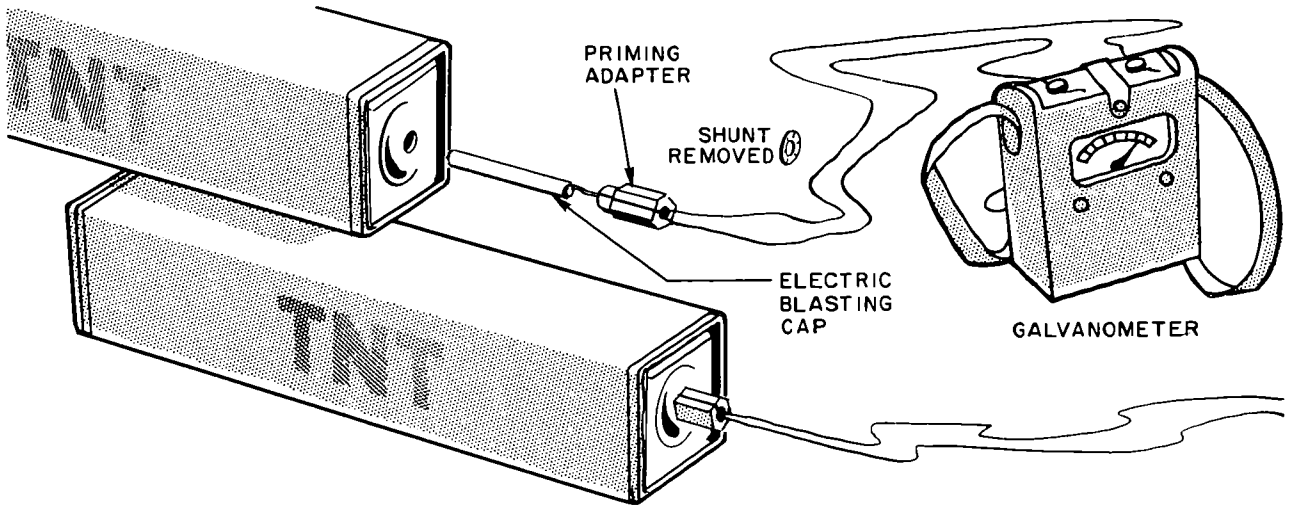



*Figure 2–19. Electric priming of demolition block with priming adapter.*

(*b*) Using string, wrap several turns around the explosive and tie any knot. Position the tie so it will be at the top of the hole when the fused cap is inserted.

(*c*) Insert fused cap into hole.

*Note. Never try to force a cap into an expedient cap well that is too small to admit it easily. Remove cap and enlarge hole.*

(*d*) Tie string around the time fuse at top of hole with two half hitches.

*b. Electric Priming.* Here again demolition blocks may or may not have threaded cap wells. If the blocks have threaded cap wells, priming adapters should be used if available. Proceed as follows:

(1) Untwist the free ends of the lead wire and fasten them to the firing wire (para 2–4).

(2) Pass the lead wires through the slot of the adapter and pull the cap into place in the adapter (fig 2–19).

(3) Insert the cap into the capwell of the explosive and screw the adapter into place.

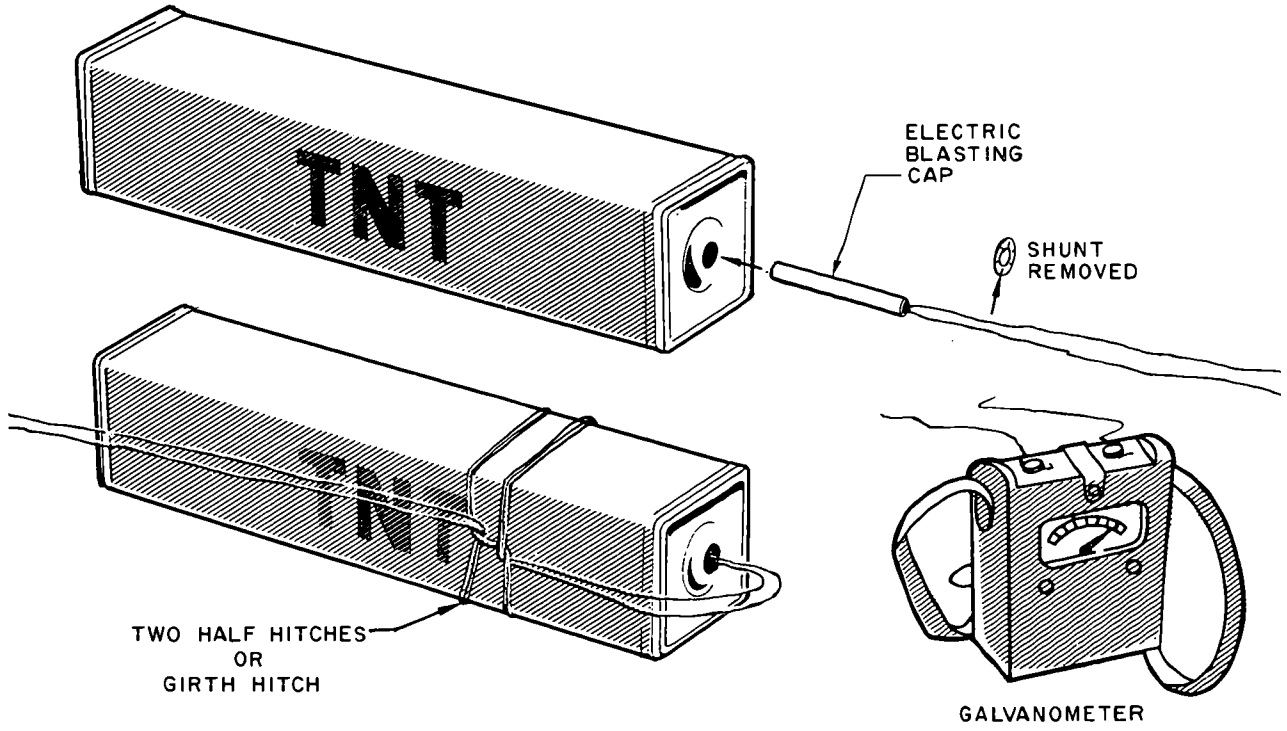



*Figure 2–20. Electric priming of demolition block without priming adapter.*

*c.* If a priming adapter is not available do the following:

(1) If the block does not have a cap well, make one in the manner described in paragraph 2–18*a* and figure 2–18.

(2) Untwist the free ends of the lead wire and fasten them to the firing wire.

(3) Insert the electric cap into the cap well and tie the lead wires around the block by two half hitches or a girth hitch (fig 2–20). Allow some slack in the wires between the blasting cap and the tie to prevent any pull on the blasting cap.

*d. Detonating Cord Priming.* Demolition blocks may be primed with detonating cord in several ways.

(1) The method which offers the greatest assurance of detonation is to affix a nonelectric blasting cap to the end of the detonating cord and place it in the demolition block similar to nonelectric priming methods (para 2–19*a*). The system is then initiated by a nonelectric or electric assembly.

(2) The common method (A, fig 2–21) lays one end of a 4-foot length of detonating cord at an angle across the explosive. The running end is then given three wraps around the block and the end laid at an angle. On the fourth wrap, slip the running end under all wraps parallel to the other end and draw tight. Initiate by an electric or nonelectric system.

(3) Alternate method No. 1 is shown in B, figure 2–21. Tie the detonating cord around the explosive block (on top of the booster, if present) with a clove hitch with two extra turns. The cord must fit snugly against the blocks and the loops must be pushed close together. Use an electric or nonelectric firing system to initiate the charge.

(4) Alternate method No. 2 places a loop of detonating cord on the explosive with four wraps around the block and loop. The running end is pulled through the eye of the loop and tightened (C, fig 2–21). This method is also initiated by an electric or nonelectric system.

*Note.* Alternate method No. 2 is more applicable to short than to long detonating cord branch lines or primers.

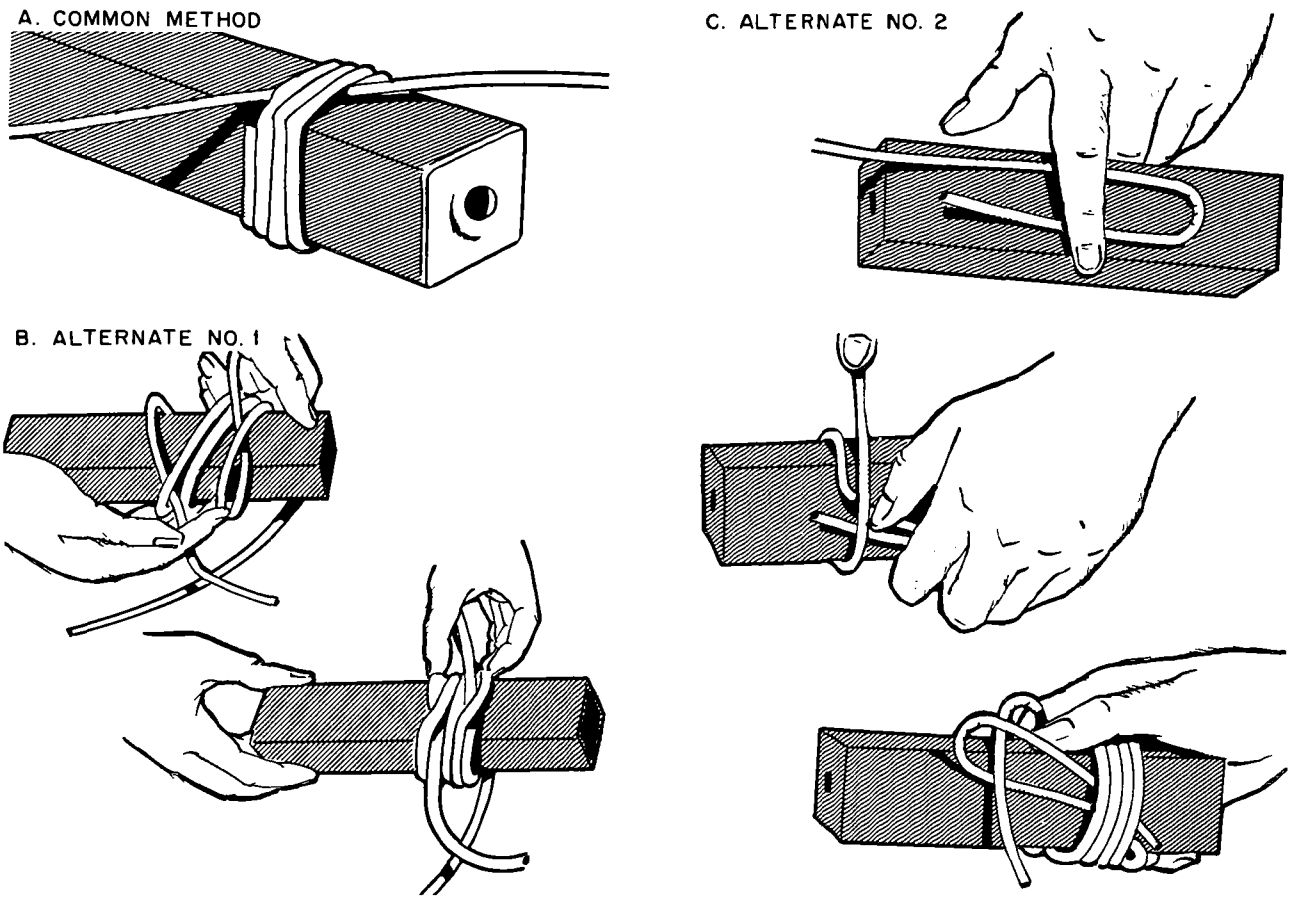



*Figure 2–21. Detonating cord priming of demolition blocks.*

## 2–19. Composition C4 and C3 Demolition Blocks

*a. Nonelectric and Electric Priming.* Whenever whole blocks or portions of blocks of plastic explosives (Composition C4 and C3) are used, prime similarly to demolition blocks without cap wells (para 2–18). Plastic explosives can be cut with a knife and then formed into almost any shape.

*b. Detonating Cord Priming.* To prime plastic explosives with detonating cord, form either of the two knots shown in figure 2–22. Then insert the knot into a block of explosive or a molded piece of explosive as shown. In either case, insure that there is at least ½ inch of explosive on all sides of the knot.

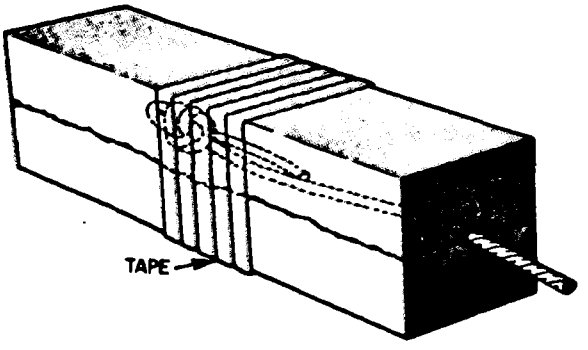
## 2–20. Sheet Explosive (M118 and M186 Demolition Charges)

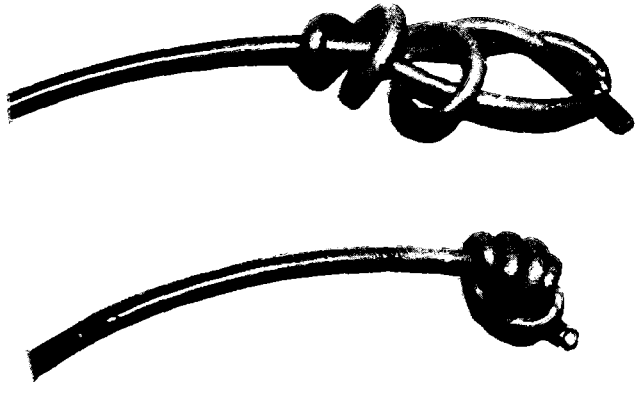
*a. Nonelectric and Electric Priming.* M118 and M186 demolition charges may be primed in the following ways:

(1) Attach blasting cap holder M8 (para 1–46) to one end or side of sheet explosive and insert electric or nonelectric blasting cap in holder until end of cap presses against sheet explosive. The blasting cap holder M8 (fig 1–25) is self-securing to sheet explosive by means of three slanted, protruding teeth which prevent withdrawal. Two dimpled spring arms firmly hold the blasting cap in the M8 holder (fig 2–23).

*Note.* This holder is supplied in each M118 and M186 demolition charge of recent manufacture. It is also available as a separate item of issue in quantities of 4,000.

OVERHAND KNOT



TRIPLE ROLL KNOT

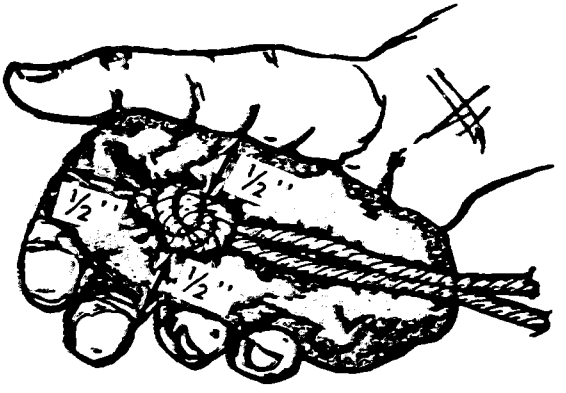



*Figure 2–22. Detonating cord priming of plastic explosive.*

(2) Cut notch approximately 1½-inches long and ¼-inch wide in sheet explosive and insert blasting cap to limit of notch; secure blasting cap with string, tape or strip of sheet explosive (fig 2–23).

(3) Place blasting cap on top of sheet explosive and secure with strip of sheet explosive at least 3″ x 3″.

(4) Insert end of blasting cap 1½ inches between two sheets of the explosive.

*b. Detonating Cord Priming.* M118 and M186 demolition charge sheet explosive may be primed with detonating cord by attaching a nonelectric blasting cap to the end of the detonating cord and following the methods outlined in *a* above. The detonating cord is then attached to a nonelectric or electric initiation system.

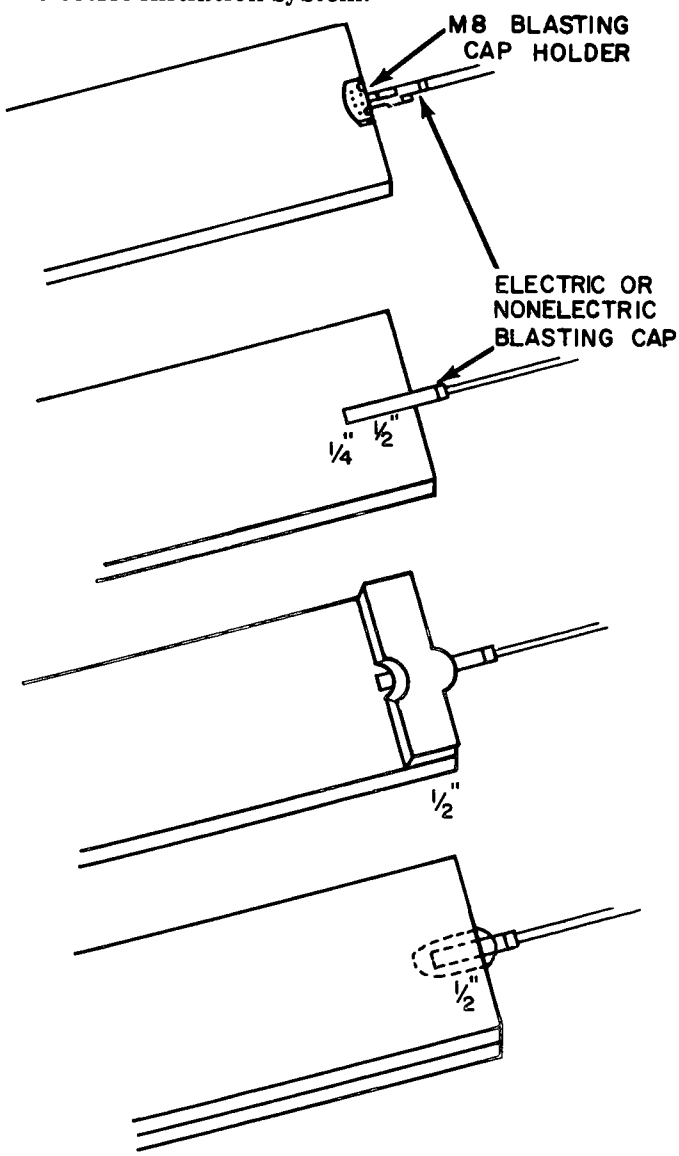



*Figure 2–23. Priming sheet explosive.*

## 2–21. Dynamite

Dynamite can be primed at either end or the side. End priming is used when a whole case is fired or when the charges placed require no tamping. Side priming is used when the charge is placed in a tamped borehole to prevent damage to the primer during placement and tamping.

*a. Nonelectric Priming.*

(1) *End priming method* (A, fig 2–24).

(*a*) Using the cap crimpers, make a cap well in the end of the dynamite cartridge.

(*b*) Insert a fused blasting cap.

(*c*) Tie the cap and fuse securely in the cartridge with string.

(2) *Weatherproof end priming method. This* method helps weatherproof the primed charge (B, fig 2–24).

(*a*) Unfold the wrapping at the folded end of the dynamite cartridge.

(*b*) Use the cap crimpers and make a cap well in the exposed dynamite.

(*c*) Insert a fused blasting cap into the cap well.

(*d*) Close the wrapping around the fuse and fasten securely with string or tape.

(*e*) Apply weatherproof sealing compound to the tie.

(3) *Side priming method* (fig 2–25).

(*a*) Use the cap crimpers and make a cap well about 1½ inches from one end of the dynamite cartridge. Slant the cap well so that the blasting cap, when inserted, will be nearly parallel with the side of the cartridge and the explosive end of the cap will be at a point at about the middle of the cartridge.

(*b*) Insert a fused blasting cap into the hole.

(*c*) Tie a string securely around the fuse and then wrap it tightly around the cartridge, making two or three turns before tying it.

(*d*) The primed cartridge may be weatherproofed by wrapping a string closely around the cartridge, extending it an inch or so on each side of the hole to cover it completely. Then cover the string with weatherproof sealing compound.

*b. Electric Priming.*

(1) *End priming method* (A, fig 2–26).

(*a*) Use the cap crimpers and make a cap well in the end of the cartridge and insert an electric blasting cap as shown in *a*(1) above.

(*b*) Tie the lead wires around the car-

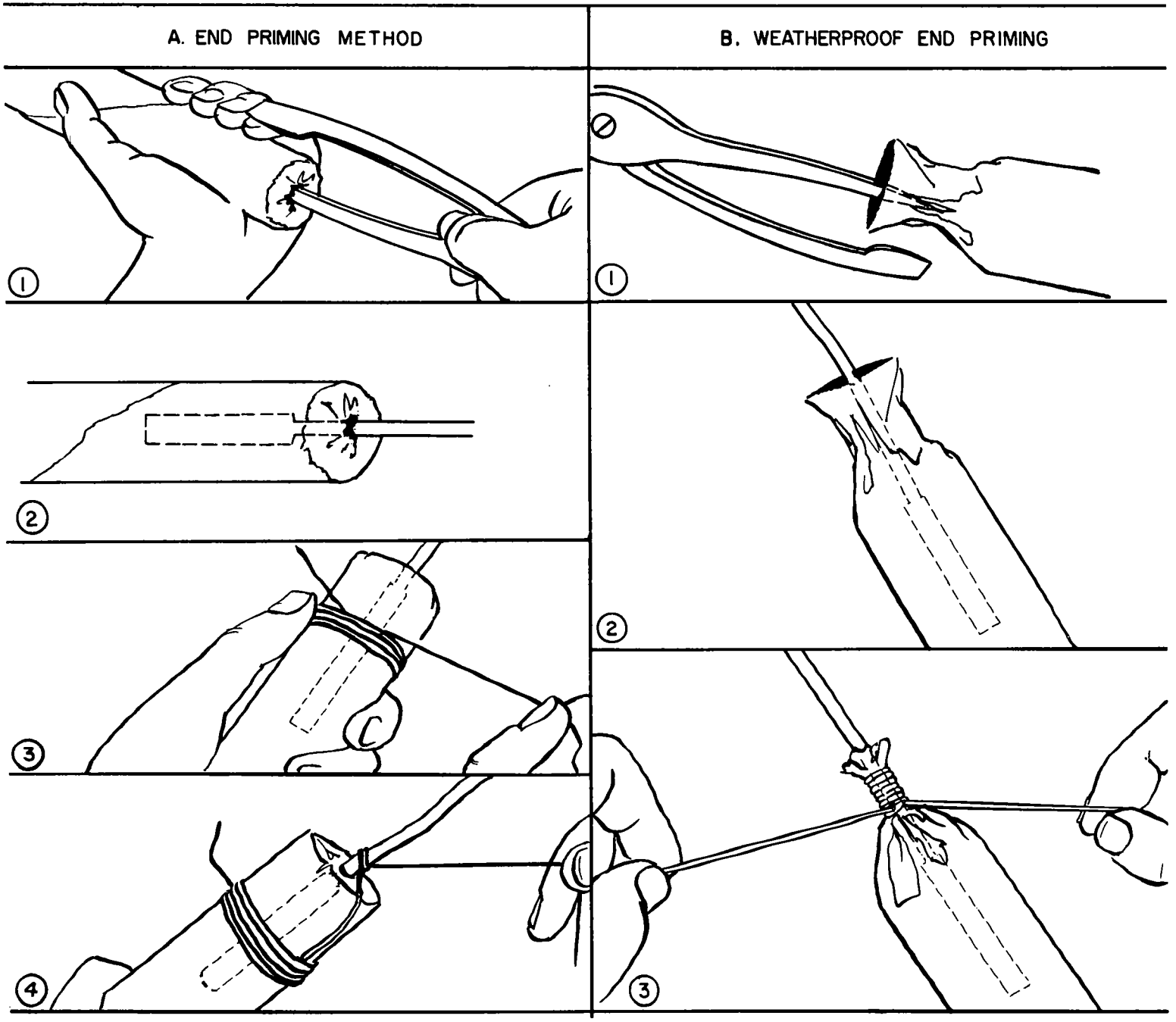



*Figure 2–24. Nonelectric end priming of dynamite.*

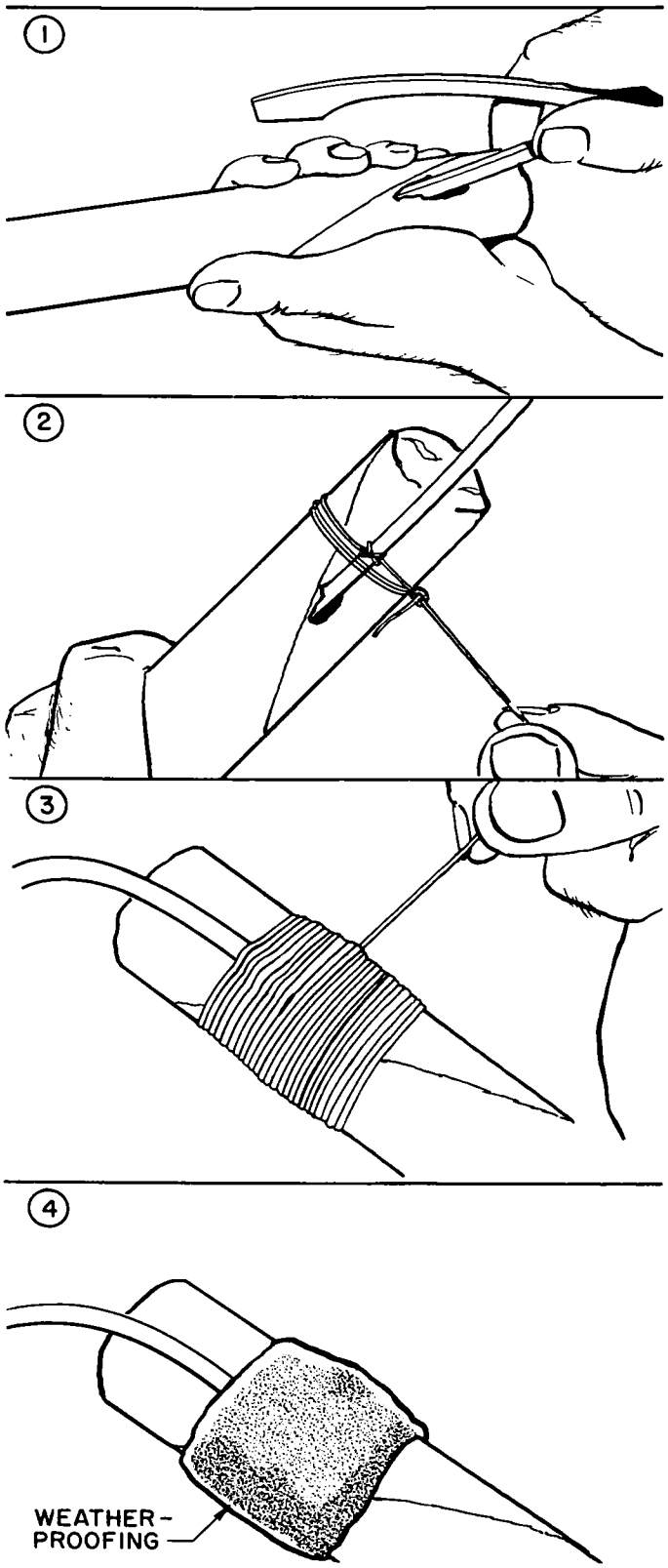



*Figure 2–25. Nonelectric side priming of dynamite.*

tridge with two half hitches or a girth hitch.

(2) *Side priming method* (B, fig 2–26).

(*a*) Make a cap well in the side of the cartridge and insert an electric blasting cap as outlined in *a*(3) above.

(*b*) Tie the lead wire around the cartridge with a girth hitch or two half hitches or fasten with string or tape.

*c. Detonating Cord Priming.* Dynamite cartridges may be primed with detonating cord by attaching a nonelectric blasting cap to the end of the detonating cord and following any of the methods for nonelectric priming outlined in *a* above. Dynamite may also be primed by lacing the detonating cord through it. This is used chiefly in boreholes, ditching, or removal of stumps. Punch four equally-spaced holes through the dynamite cartridge and lace the detonating cord through them as shown in figure 2–27.

## 2–22. 40-Pound Ammonium Nitrate Cratering Charge

*a. Nonelectric Priming* (fig 2–28).

(1) Place a fused nonelectric blasting cap in the cap well on the side of the container.

(2) Tie a string around the fuse and then around the cleat above the cap well.

(3) Dual prime as outlined in *d* below.

*b. Electric Priming* (fig 2–28).

(1) Place an electric blasting cap in the cap well on the side of the container.

(2) Tie the lead wires around the cleat above the cap well.

(3) Dual prime as outlined in *d* below.

*c. Detonating Cord Priming* (A, fig 2–29).

(1) Pass the end of the detonating cord through the tunnel on the side of the can.

(2) Tie an overhand knot on the portion passed through at least 6-inches from the end.

(3) Dual prime as outlined in *d* below.

*d. Dual Priming* (B, fig 2–29). To insure positive detonation of the ammonium nitrate cratering charge all charges should be dual primed with a 1-pound block of explosive taped to the side of the charge near the cap well or detonating cord tunnel to detonate the TNT booster in the center of the charge. This demolition block may be primed by the same method the cratering charge is primed. Both charges should be primed to detonate simultaneously.

*e. Precautions.* As ammonium nitrate is hygroscopic and becomes ineffective if it has absorbed

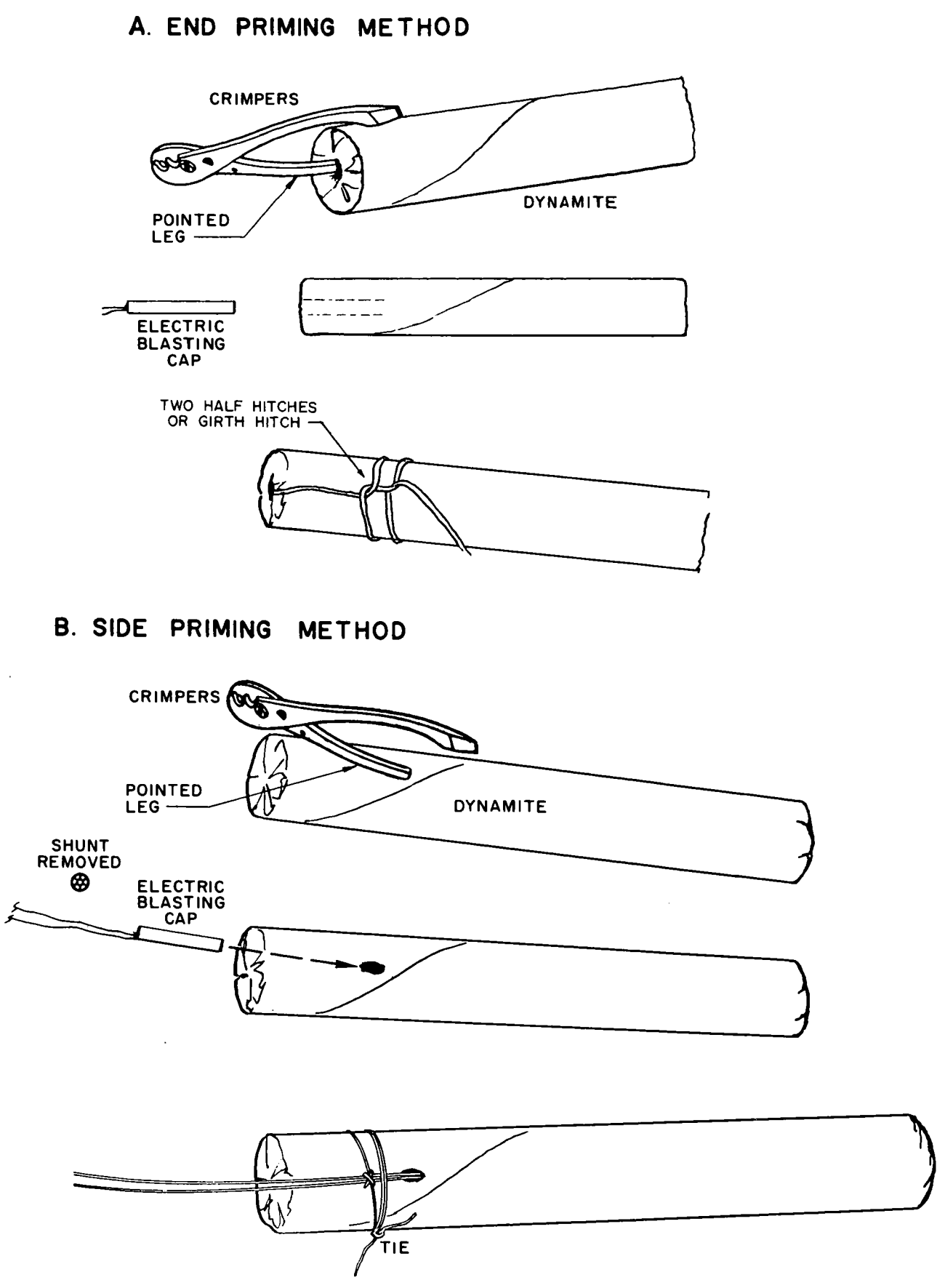



*Figure 2–26. Electric priming of dynamite.*

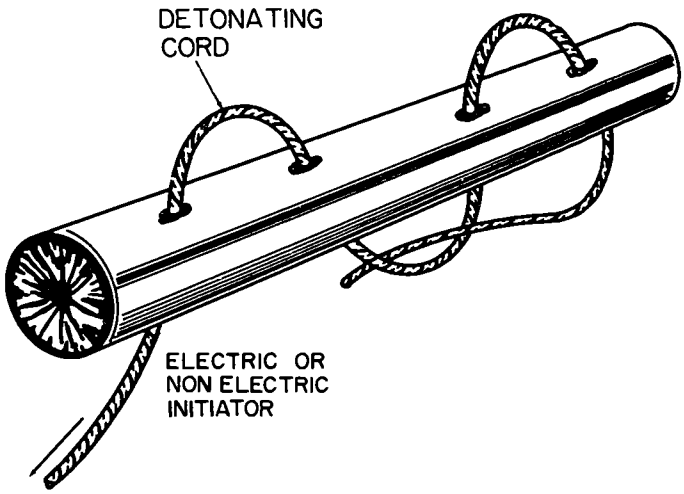



*Figure 2–27. Detonating cord priming of dynamite.*

moisture (para 1–33), the metal container must be carefully inspected for damage or rusting that would indicate that the ammonium nitrate had absorbed moisture. Damaged or rusted charges should not be used. For safety in priming use detonating cord whenever charges are placed underground.

## 2–23. Shaped Charges

*a. Nonelectric and Electric Priming.* The M2-A3, M2A4, M3 and M3A1 shaped charges have a threaded cap well at the top of the rear cone. They may be primed by means of a blasting cap and priming adapter as shown in figure 2–30. If a priming adapter is not available, the primer may be held in the cap well with string, piece of cloth or tape.

*b. Detonating Cord Priming.* Shaped charges are primed with detonating cord by attaching a nonelectric blasting cap to the end of the detonating cord and following the procedure in *a* above.

*c. Dual-Priming.* As shaped charges must be detonated from the center of the rear of the cone for maximum effectiveness, conventional methods

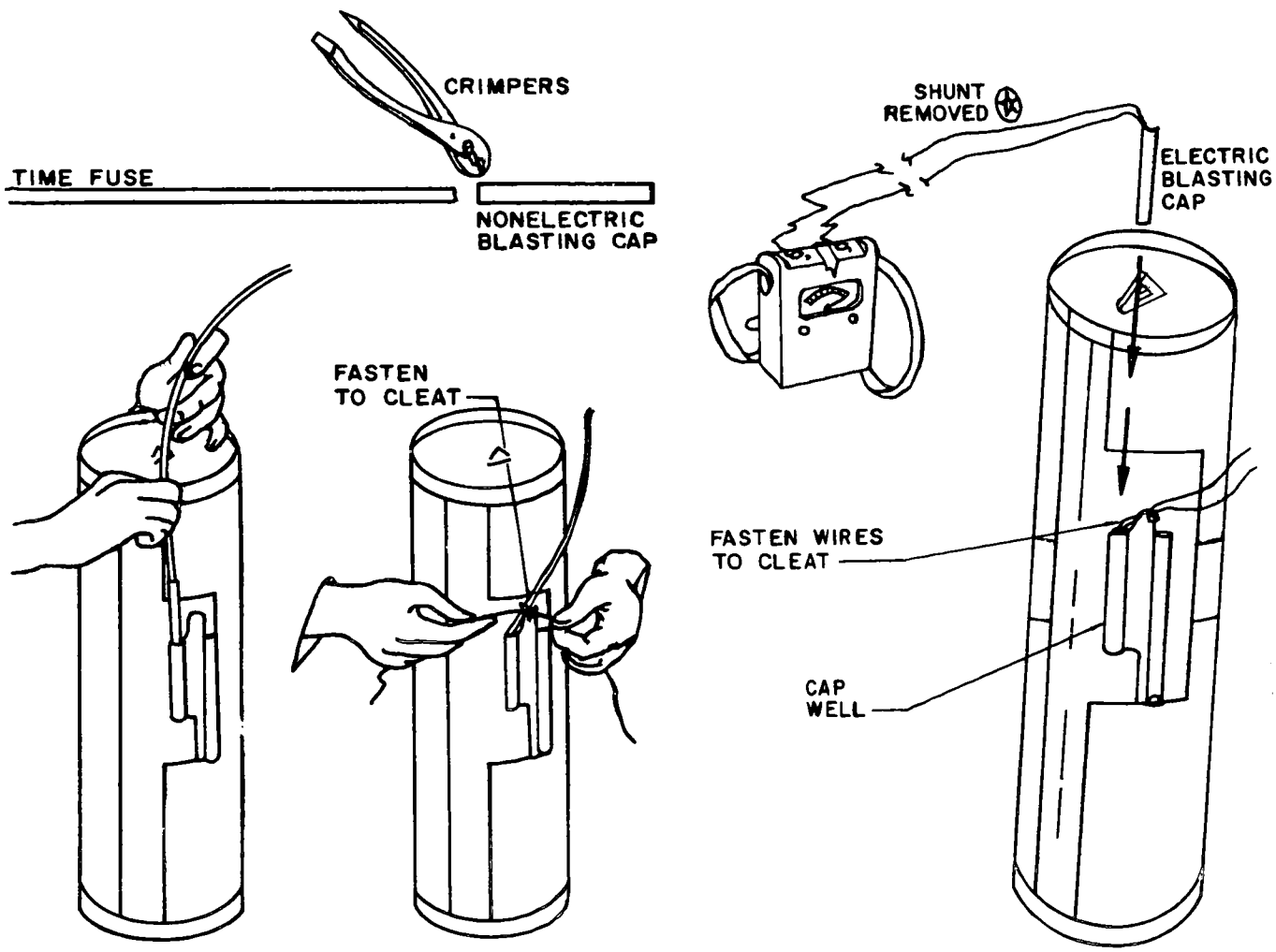



*Figure 2–28. Nonelectric and electric priming of ammonium nitrate cratering charge.*

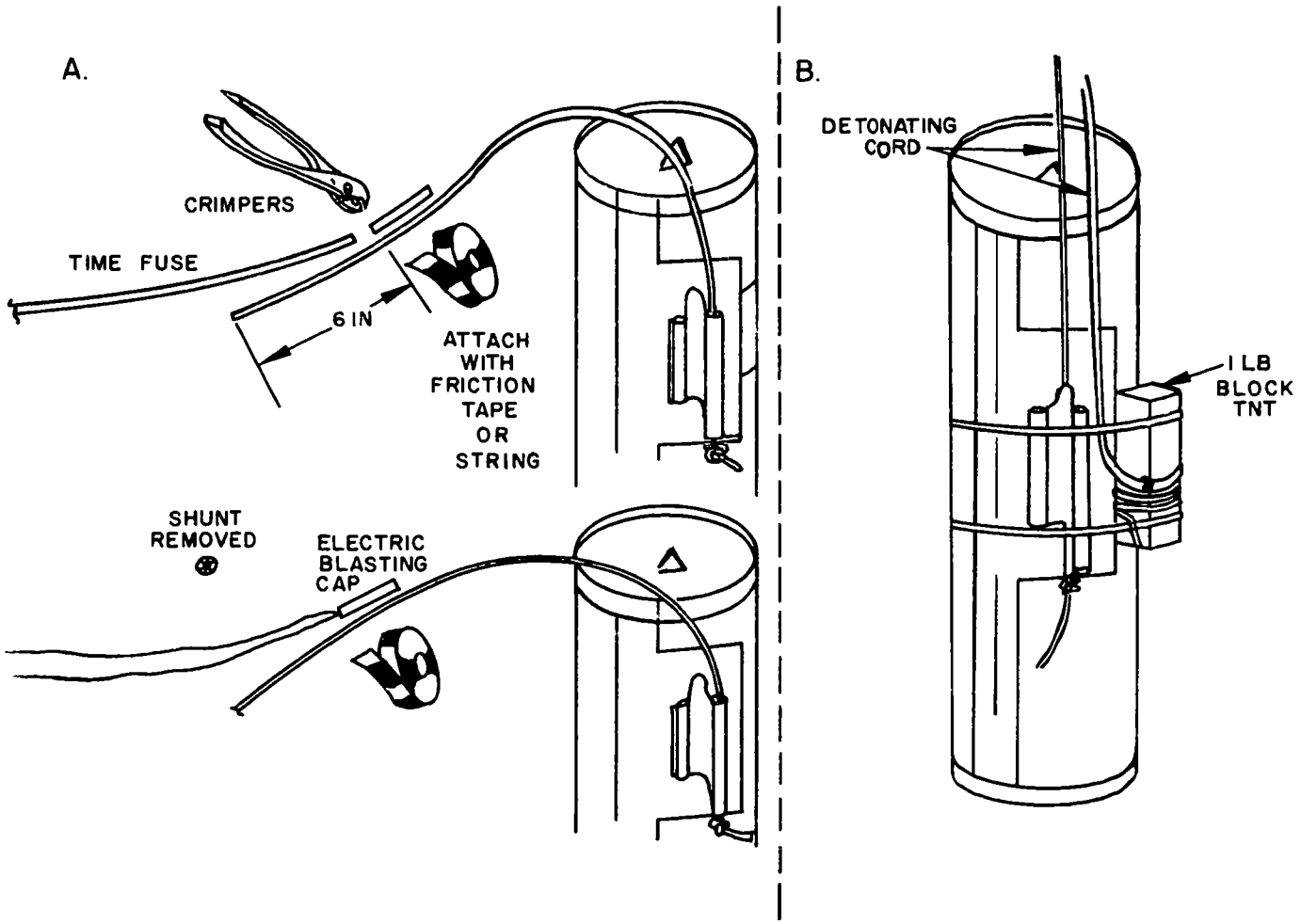



*Figure 2–29. Detonating cord priming and dual priming of ammonium nitrate cratering charge.*

of dual priming are not applicable to shaped charges.

## 2–24. Bangalore Torpedo

*a. Nonelectric Priming.* The bangalore torpedo may be primed by assembling a length of time blasting fuse and a nonelectric blasting cap in a priming adapter and screwing the assembly into the cap well of a torpedo section (A, fig 2–31). A section may also be primed nonelectrically by a pull type firing device, with a nonelectric blasting cap crimped on the base, screwed into the cap well (B, fig 2–31).

*b. Electric Priming.* The bangalore torpedo may be primed electrically by assembling a blasting cap and priming adapter and screwing the assembly into the cap well of a torpedo section (C, fig 2–31).

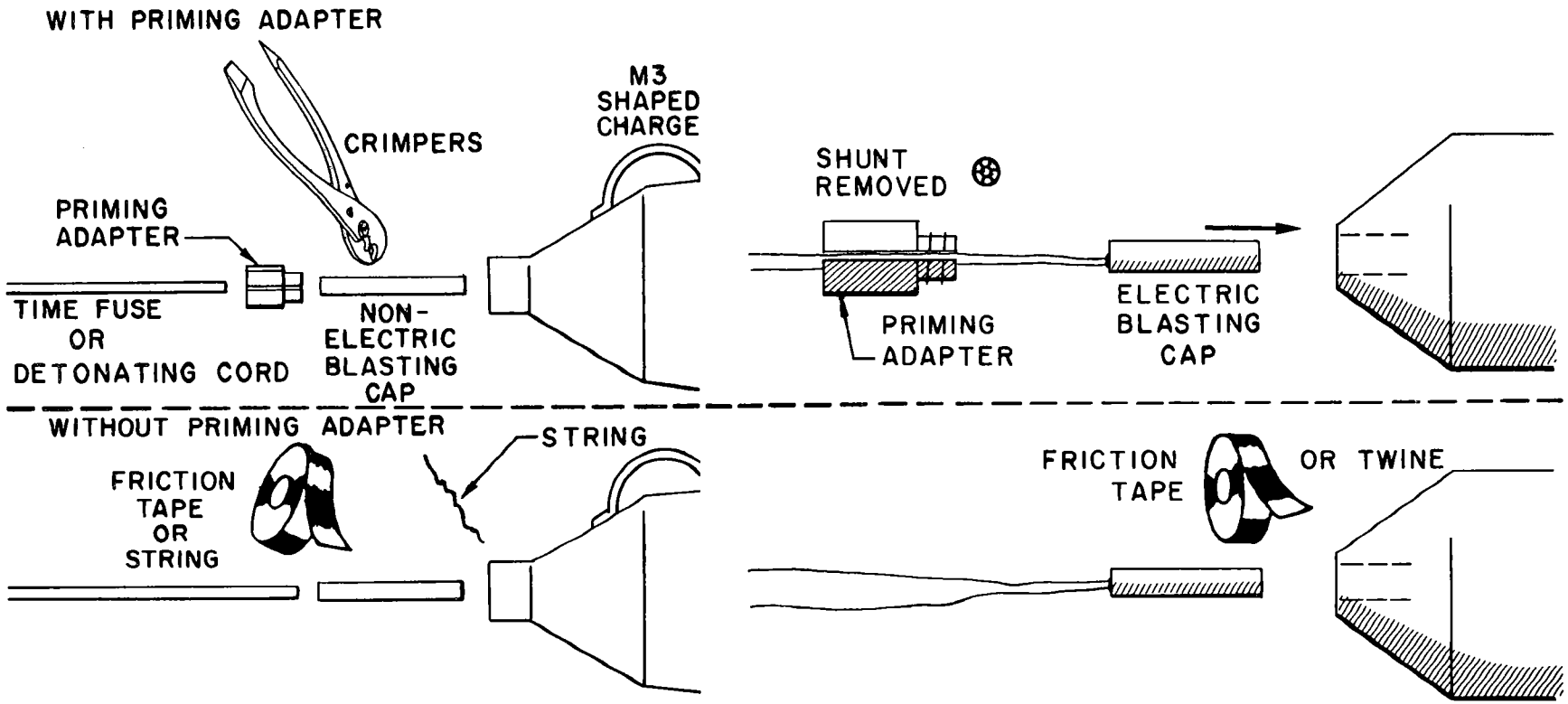



*Figure 2-30. Nonelectric and electric priming of shaped charges.*

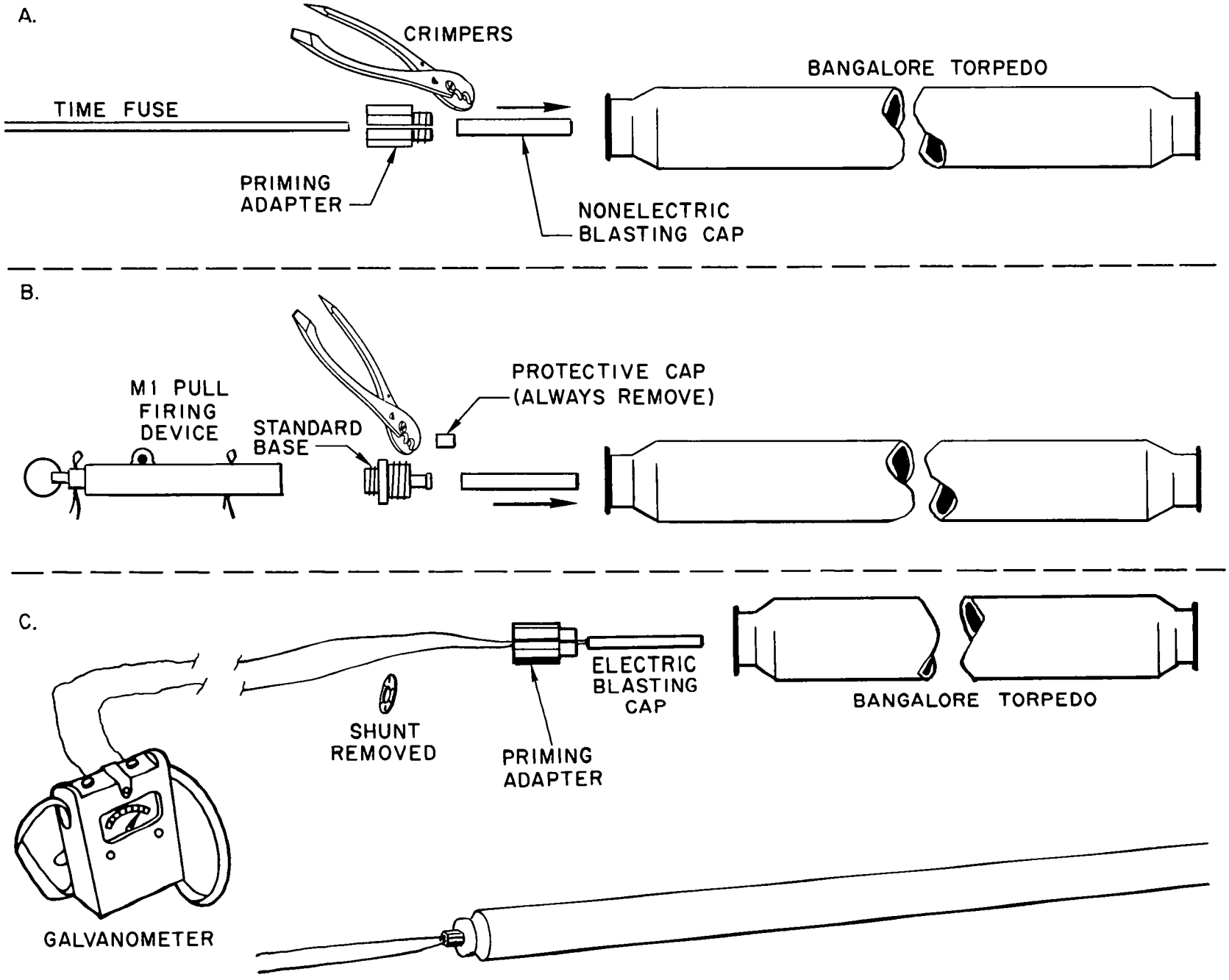



*Figure 2–31. Nonelectric and electric priming of bangalore torpedo.*

# CHAPTER 3

# CALCULATION AND PLACEMENT OF CHARGES

## Section I. INTRODUCTION

### 3–1. Critical Factors in Charge Calculations

The amount of explosive used in any demolition project is determined by formula calculations based on the critical factors listed below.

*a. Type and Strength of Material.* A demolition target may be constructed of timber, steel, concrete or some other material. Concrete may be reinforced with steel thereby increasing its strength. Formulas for computing specific charges for timber, steel, concrete, and so on, are given in succeeding sections of this chapter.

*b. Size and Shape of Target.* Consideration must be given to the size and shape of the target. For example, large targets, such as concrete piers, and oddly shaped targets, such as steel I-beams, may be more economically attacked by multiple charges than a single charge.

*c. Desired Demolition Effect.* The extent of demolition desired and other desired effects, such as direction of falling trees to construct an abatis, must be considered.

*d. Type of Explosive.* The particular characteristics of each type of explosive make it applicable to certain demolition projects, in preference to others. The relative effectiveness of each type of explosive must be considered in each formula calculation. Explosive charges used in military operation and their relative effectiveness factors are shown in table 1–2.

*e. Size and Shape of Charge.* The amount of explosive is calculated by each demolition formula, but, in the absence of special placement techniques, when external charges are used, a flat square charge with a thickness to width ratio of 1 to 3 or more will give acceptable results. In general, charges less than 5 pounds should be 1 inch thick (one M112 demolition block; charges 5 pounds to 40 pounds should be 2 inches thick (one M5A1 demolition block); and charges 40 pounds or more should be 4 inches thick (one M–183 demolition assembly). A more detailed discussion of charge thickness is found in paragraph 3–2b.

*f. Charge Placement.*

(1) Charges should be placed at the position that will provide maximum effectiveness. For cratering, they are placed in holes in the ground; for breaking or collapsing stone or concrete, they are properly located on the surface or in boreholes; for cutting timber they may be tied on the outside or placed in boreholes, whichever is the more practical.

(2) Charges are fastened to the target by wire, adhesive compound, tape, or string; propped against the target by means of a wooden or metal frame made of scrap or other available materials; or placed in boreholes. Special accessories are issued for this purpose—adhesive compound, the rivet-punching powder-actuated driver, the earth auger, and pneumatic tools (para 1–58).

*g. Method of Initiation.* Generally the method of initiation is not critical unless the demolition charge is of a special type such as a shaped charge or diamond charge.

*h. Tamping.* The detonation of an explosive produces pressure in all directions. If the charge is not completely sealed in or confined or if the material surrounding the explosive is not equally strong on all sides, the explosive force breaks through the weakest spot and part of the destructive effect is lost. To retain as much of this explosive force as possible, material is packed around the charge. This material is called tamping material or tamping, and the process, tamping. On the other hand, an internal charge (one placed in the target to be destroyed) is confined by packing material in the borehole on top of the charge as is done in quarrying and cratering. This is called stemming.

### 3–2. Principles of Demolition

*a. Effects of Detonation.* When a high explo-

sive detonates, the explosive changes violently into compressed gas at extremely high pressure. The rate of change is determined among other things by the type of explosive and the density, confinement, and dimensions of the charge. Thus the detonation releases tremendous pressure in the form of a compressive shock wave which, although it exists for only a few micro-seconds at any given point, may shatter and displace objects in its path as it proceeds from its point of origin. This shock wave is transmitted directly to any substance in contact with the charge, other characteristics being equal. A high explosive charge detonated in direct contact with a solid object produces three different easily detectable destructive effects.

(1) *Cratering.* The surface of the object directly under the explosive charge will be cratered. On a concrete surface the high pressure of the compressive shock wave crumbles the material in the immediate vicinity of the charge, forming the crater. On a steel target an indentation or depression with an area about the size of the contact area of the charge is made in the surface of the plate.

(2) *Spalling.* Providing that the charge is of sufficient size, the opposite side of the object will be spalled. The strong compressive shock wave transmitted into the material expands spherically losing energy as it moves through the material. If the target has a free surface on the side opposite the charge, the compressive shock wave will be reflected as a tensile shock wave from that free surface because of the difference in density between the target and the air. Reflection of the compressive shock wave as a tensile shock wave causes spalling of the target free surface, wherein a portion of the material is literally torn from the free surface. On a concrete wall, depending upon the relative size of the charge and thickness of the wall, the crater and spalls meet and form a hole through the wall. On a steel plate, usually only one spall, approximately the shape of the explosive charge, is thrown from the plate.

(3) *Cracking.* If the explosive charge is of sufficient size the high pressure gases from the explosive charge will create a pressure load on the object that will crack and displace the material beyond the extent of the crater and spall. These cracks will radiate from the charge position. On concrete walls, this cracking may be extensive enough to break the wall into a large number of chunks which are projected away from the charge position. On steel plates, the material may be bent away from the charge position.

*b. Significance of Charge Dimensions.* The force of an explosion is proportional to the quantity and power of the explosive, but the destructive effect depends, in part, on the manner that the explosive force is directed at the target. An optimum relation must exist between the area of the charge in contact with the target and charge thickness in order to transmit the greatest shock. If any given weight of explosive, calculated to cut a given target, is spread too thinly, there will be insufficient space for the shock wave to attain full velocity before striking the target. The shock wave will tend to travel more nearly parallel than normal to the surface over much of the area, and the volume of the target will be excessive for the strength of the shock wave. On the other extreme, a thick charge with a small contact area will transmit the shock wave over too little of the target with excessive lateral loss of energy. Test results have demonstrated that the optimum ratio of charge thickness to charge width is about 1:3 for contact steel cutting charges on structural steel 3 inches thick or less, and ranges from about 1:6 to 1:14 for rectangular external untamped breaching charges for reinforced concrete from 1 to 7 feet thick.

*c. Significance of Charge Placement.* The destructive effect of an explosive charge is also dependent upon the contact between the explosive and the target and the location of the charge in relation to target size and shape.

(1) For the maximum destructive effect an explosive charge with a configuration and dimensions optimum for the size and shape of the target must be detonated in intimate contact with the target. Any significant air or water gap between the target and the explosive will not transmit the complete force of the shock wave into the target. Certain explosives, such as sheet explosive or plastic explosives, are more desirable for certain targets because they may be cut or molded to fit odd shaped targets.

(2) Explosive charges are placed to act through the least dimension of the target whenever possible. In terms of the maximum destructive effect for the least amount of explosive, internal charges are the best. The tamping of external charges increases their destructive effect.

## 3-3. Types of Charges

*a. Internal Charges.* Internal charges are

charges placed in boreholes in the target. These are confined by tightly packing sand, wet clay, or other material (stemming) into the opening. This is tamped and packed against the explosive to fill the hole all the way to the surface. In drill holes, the explosive (usually dynamite) is tamped as it is loaded into the hole. Refer to TM 5–332 for details of quarry practice.

*b. External Charges.* These charges are placed on the surface of the target. They are tamped by covering them with tightly packed sand, clay, or other dense material. Tamping may be in sandbags or loose. For maximum effectiveness the thickness of the tamping should at least equal the breaching radius. Small breaching charges on horizontal surfaces are sometimes tamped by packing several inches of wet clay or mud around them. This process is called mudcapping.

### 3–4. Charge Selection and Calculation

*a. Charge Selection.* The selection of the optimum explosive charge for successful demolition operations is a balance between the important factors listed above and the practical aspects of the type of target, the type and amount of explosives available, the amount and type of material (such as sandbags) and equipment available, the amount of manpower available, and, probably most important, the time available to accomplish the mission. Formulas for computing specific charges and methods of their placement are given below. Formulas based on metric measurements are given in appendix B.

*b. Charge Calculation.* The formulas in this chapter give the weight of explosive required for a demolition task $P$ in pounds of TNT. If explosives other than TNT are used, the value of $P$ must be adjusted according to the strength of these other explosives. The adjusted value of $P$ corrected weight of explosive required, is computed by dividing the $P$ value for TNT by the relative effectiveness factor for the explosive to be used.

*c. Rounding-off Rule.* When using explosives, *never* use less than the calculated amount. Some explosives like plastic explosive (C4) and sheet explosive (M118 and M186) can be cut to the desired amount, while with other explosives the ability to size explosives is limited. For charges calculated by formula, use the following round-off method:

(1) Calculate the weight of a single charge for TNT using the selected demolition formula to at least two decimals.

(2) Divide by the relative effectiveness factor, if required.

(3) Round up answer for single charge to next package size.

(4) Multiply answer for single charge by the number of charges to obtain the total amount of explosives required.

## Section II. TIMBER-CUTTING CHARGES

### 3–5. Size and Placement of Charge

*a. Type of Explosive Used.* For tamped internal charges in boreholes, dynamite is generally used, as it is the most convenient to place because of the size of the cartridge and is powerful enough because it is confined. For untamped concentrated external charges, block explosive (TNT, Tetrytol, and Composition C4) is used, as it is easily tied or fastened on its effectiveness in relation to that of TNT (relative effectiveness factor). For untamped external ring charges, plastic explosive (composition C4) or sheet explosive (M118 or M186) is used, as it is easily fastened to the target and molded around the target. It is impractical to attempt to cut all kinds of timber with charges of a size calculated from a single formula. There is too much variation in different kinds of timber from locality to locality. Accordingly, test shots must be made to determine the size of the charge to cut a specific type of timber. Formulas for the calculation of these test shots are provided for tamped internal charges, and untamped external charges. They are as follows:

*b. Formula for Tamped Internal Charges.* Tamped internal cutting charges may be calculated by the following formula:

$$P = \frac{D^2}{250} \text{ or } P = .004\,D^2 \text{ where,}$$

$P$ = Pounds of TNT required,

$D$ = diameter or least dimension of dressed timber, in inches, and

$\frac{1}{250}$ = .004 = constant

The amount of explosive required to cut a 15-inch diameter tree, using tamped internal charges, is determined as follows:

$$P = \frac{D^2}{250}$$

$$P = \frac{(15)^2}{250} = \frac{225}{250} = 0.90 \text{ or } 1 \text{ pound of TNT}$$

*Note.* See rounding off rule, paragraph 3–4*c*.

*c. Internal Charge Placement.* The charge is

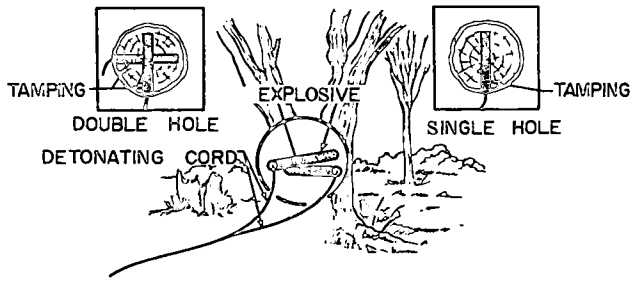



*Figure 3-1. Internal timber cutting charge.*

placed in a borehole parallel to the greatest dimension of cross section and tightly tamped with moist earth. If the charge is too large to be placed in one borehole, bore two holes side by side in dimensional timber. On round timber, bore the two holes at approximately right angles to each other, but not to intersect (fig 3-1). Both boreholes are tamped and the charges are fired simultaneously.

*d. Formula for Untamped External Charges.* For cutting trees, piles, posts, beams or other timber members using explosives as an untamped external charge the following formula is used:

$$P = \frac{D^2}{40} \text{ or } P = .025\ D^2 \text{ where,}$$

$P$ = pounds of TNT required,

$D$ = diameter of round timber, or least dimension of dressed timber, in inches, and

$\frac{1}{40} = .025$ = constant.

Adjustment for explosive other than TNT will be made by dividing by the relative effectiveness factor (table 1-2) that pertains to the particular explosive being used. The amount of explosive required to cut a round timber 30 inches in diameter using an untamped external charge is determined as follows:

$$P = \frac{D^2}{40}$$

$$P = \frac{(30)^2}{40} = \frac{900}{40} = 22.50 \text{ pounds of TNT.}$$

*e. Concentrated External Charge Placement.* For maximum destructive effect concentrated charges should be of rectangular configuration, 1 to 2 inches thick and approximately twice as wide as they are high. Charges are placed as close as possible to the surface of the timber (fig 3-2). Frequently it is desirable to notch the tree to hold the explosive in place. If the tree or timber is not round and the direction of fall is of no concern, the explosive is placed on the widest face so that the cut will be through the least thickness. The tree will fall toward the side where the explosive is placed, unless influenced by lean or wind. Charges on rectangular or square dressed timber are placed as shown in figure 3-3.

*Figure 3-2. External timber cutting charge.*

*f. Ring Charge Placement.* The ring charge (fig 3-4) is placed as a band of explosive completely circling the tree. The width of the explosive band should be as wide as possible, and a minimum of ½ inch thick for small-diameter trees, and 1 inch thick for medium- and large-diameter trees up to 30 inches. This technique is used when the direction of fall is not important and the elimination of stumps is important, e.g.,

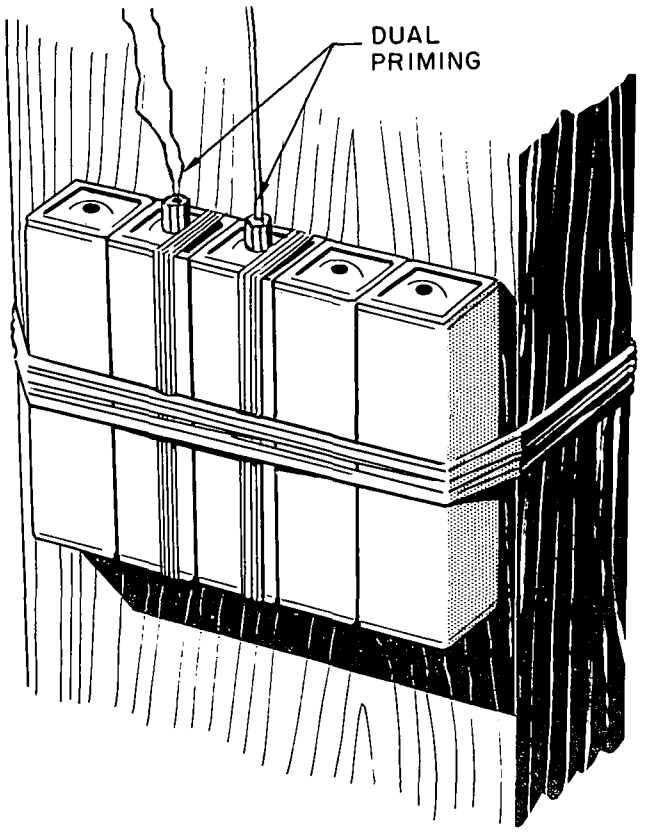



*Figure 3–3. External cutting charge on rectangular timber.*

explosive clearing for a helicopter landing zone. The amount of explosive used is calculated by the external charge formula.

## 3–6. Abatis

*a. Formula for Partially Cutting Trees To Create an Obstacle or Abatis.* When cutting trees and leaving them attached to the stumps to create an obstacle, the formula $P = \frac{D^2}{50}$ or $P = 0.02\ D^2$ is used to compute the amount of TNT required for the test shot. The result of the test shot will determine the need for increasing or decreasing the amount of explosives required for subsequent shots.

*b. Placement of Abatis Charges.* Charges for making fallen-tree obstacles are placed as a concentrated external charge the same as in paragraph 3–5*e*, except that they are placed approximately 5 feet above ground level. The tree will fall toward the side where the explosive is placed, unless influenced by lean or wind. To make the direction of fall more certain, a "kicker charge", a one-pound block of explosive, placed about two-thirds of the distance up the tree on the opposite side may be used (fig 3–2).

*c. Special Considerations.* To be effective these obstacles should be at least 75 meters in depth

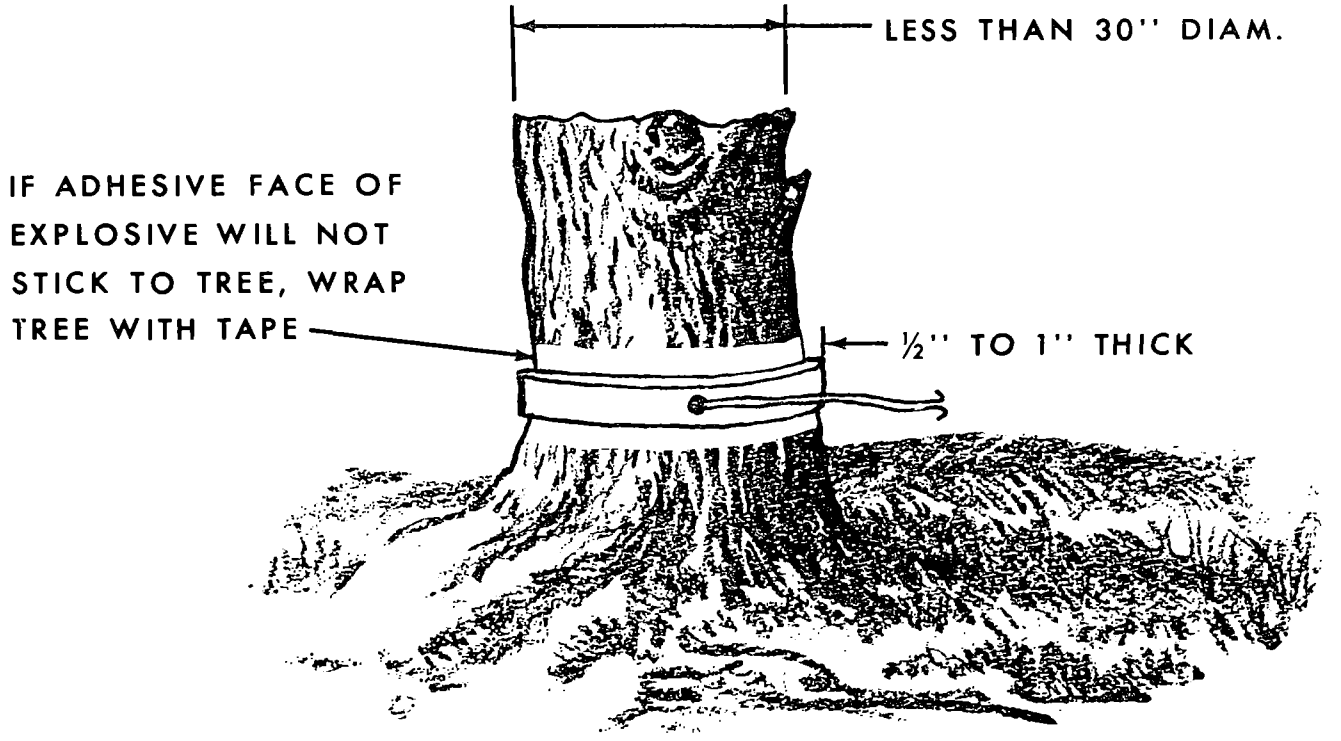



*Figure 3–4. Timber cutting ring charge.*

and the felled trees should extend at a 45° angle toward the enemy. The trees on one side of the road should be cut simultaneously, followed by the cutting of the trees on the other side of the road. Delayed blasting of the second row of trees is necessary to provide time for the trees in the first row to fall and thereby eliminate the possibility of trees deflecting one another from their desired direction of fall. Likewise, in selection of trees to blast for abatis obstacles, the trees in a row should be selected at spacings great enough to allow the trees to fall without interference from other falling trees in the same row. To make the obstacles more difficult to remove, they should be mined, boobytrapped, entangled with barbed wire or concertina, and covered by fire.

## Section III. STEEL-CUTTING CHARGES

### 3–7. Cutting Steel With Explosives

*a. Important Factors.* In the preparation of steel-cutting charges, the factors of type, size and placement of the explosive are important for successful operations. The confinement or tamping of the charge is rarely practical or possible. Formulas for the computation of the size of the charge vary with the type of steel—structural, high carbon, and so forth. Placement of the charge in direct contact with the target is more important with steel than with other materials.

*b. Explosive used.* Steel-cutting charges are selected because of their cutting effect and adaptability to placement. Plastic explosive (C4) and sheet explosive (M118) are the most desirable as they have high detonation velocity and other characteristics that give them great cutting power. Plastic explosive (C4) in the M5A1 demolition block can be cut and molded to fit tightly into the grooves and angles of the target, particularly structural steel, chains, and steel cables; but the M112 block, (C4) is more adaptable because its size and shape, which approaches optimum configuration for most steel cutting charges, allows it to be used without cutting or reshaping. The M112 block is also more adaptable to steel targets because of its adhesive compound on one face, which fixes it securely to the target. Sheet explosive (M118 or M186), because of its width (3 inches), thickness (¼ inch), and adhesive is more desirable for some steel targets than either the M5A1 or M112 demolition blocks. TNT, on the other hand, is adequate, generally available, and cast into blocks that may be readily assembled and fixed, but not molded to the target.

*c. Types of Steel.*

(1) *Structural.* Examples of this are I-beams, wide-flange beams, channels, angle sections, structural tees, and steel plates used in building or bridge construction. These are the types of steel usually present in demolition projects. The formulas in paragraph 3–8*a*(1) and *b*(1), are applicable to structural steel, except for cutting slender structural bars (2 inches or less in diameter) where placement difficulties require the use of the formulas in paragraphs 3–8*a*(2) (*b*) and *b*(2).

(2) *High-carbon and alloy steel.* High-carbon steel is used in the construction of metalworking dies and rolls. Gears, shafts, tools, and plowshares generally are made of alloy steel. Chains and cables also are often made from alloy steel; some, however, are made of a high-carbon steel. The formulas in paragraphs 3–8*a* (2) (*a*) and *b* (3), apply to high carbon and alloy steel.

(3) *Nickel-molybdenum steel and cast iron.* Cast iron, being very brittle, breaks easily, but nickel-molybdenum steel cannot be easily cut by conventional steel cutting charges. The jet from a shaped charge will penetrate it, but cutting will require multiple charges or a linear shaped charge. Nickel-molybdenum steel shafts can be cut with the diamond charge in one shot; however, the saddle charge will not cut them. Accordingly, nickel-molybdenum steel should be cut by some method other than explosives—thermite and acetylene or electric cutting tools, for example.

### 3–8. Size of Charge

The amount of charge is determined by the type and size of the steel and the type of charge to be used.

*a. Formulas for Block Explosive Charges.* When block explosives such as TNT, tetrytol, or cased plastic explosive are used to cut steel sections the following formulas should be used.

(1) *Formula for structural steel.* Charges to cut I-beams, builtup girders, steel plates, columns, and other structural steel sections are computed by formula as follows:

$P = \frac{3}{8} A$ or $P = 0.375\ A$ where,
$P$ = pounds of TNT required,
$A$ = cross-section area, in square inches, of the steel member to be cut, and
$\frac{3}{8} = 0.375$ = constant.

(2) *Formula for other steels.*

(a) The formula below is recommended for the computation of block cutting charges for high-carbon or alloy steel, such as that found in machinery.

$P = D^2$
$P$ = pounds of TNT
$D$ = diameter or thickness in inches of section to be cut.

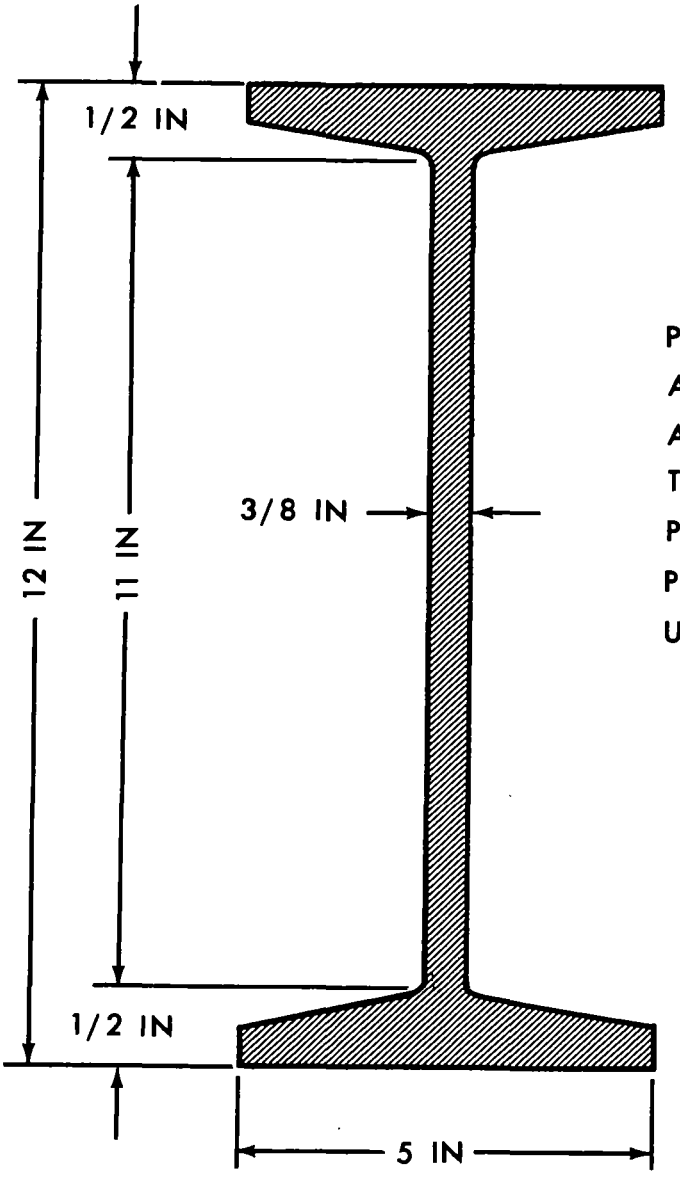
(b) For round steel bars, such as concrete reinforcing rods, where the small size makes charge placement difficult or impossible and for chains, cables, and steel rods, of a diameter of 2 inches or less, use

$P = D$
$P$ = pounds of TNT
$D$ = diameter in inches of section to be cut.

Such steel, however, may be cut by "rule of thumb:"

For round bars up to 1 inch in diameter, use 1 pound TNT.
For round bars over 1 inch up to 2 inches in diameter, use 2 pounds of TNT.

(3) *Railroad rail.* The height of railroad rail is the critical dimension for calculating explosive required. Rails 5 inches or more in height may be cut with 1 pound of TNT. For rails less than 5 inches in height, ½ pound of TNT is adequate.




CHARGE CALCULATION - TNT

P = 3/8 A
AREA OF FLANGE = 2 × 1/2 × 5 = 5 SQ IN
AREA OF WEB = 3/8 × 11 = 4 1/8 SQ IN
TOTAL AREA (A) = 9 1/8 SQ IN
P = 3/8 A
P = 3/8 × 9 1/8 = 3 27/64
USE 3 1/2 LB OF TNT

*Figure 3–5. Calculation of charge to cut steel I-beam.*

P = D
P = POUNDS OF TNT REQUIRED, AND
D = DIAMETER IN INCHES OF STEEL CHAIN TO BE CUT
D = 1 INCH

P = 1
P = 1 POUND OF TNT, IF BLOCK WILL BRIDGE LINK; IF NOT, USE TWO BLOCKS, ONE ON EACH SIDE OF LINK

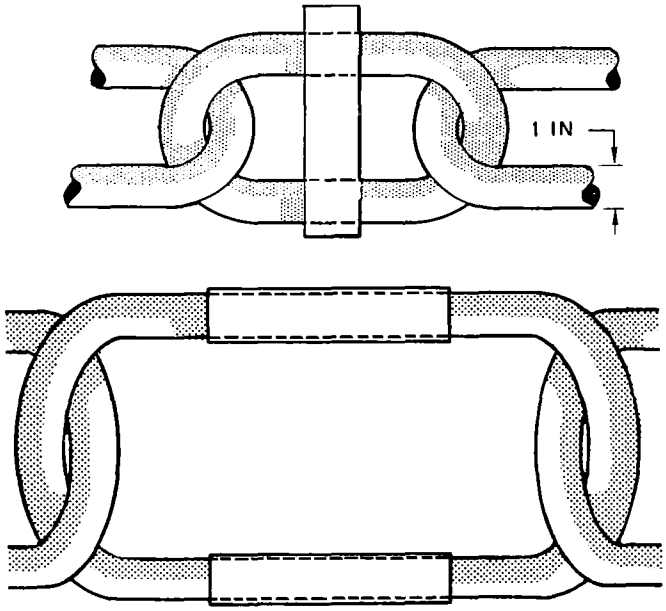



*Figure 3-6. Calculation of charge to cut steel chain.*

(4) PROBLEM:
Determine the amount of TNT required to cut the steel I-beam shown in figure 3-5. The solution is given in the figure.

(5) PROBLEM:
How much TNT is needed to cut the steel chain in figure 3-6? The solution is given in figure 3-6. Notice that the link is to be cut in two places (one cut on each side) to cause complete failure. If the explosive is long enough to bridge both sides of the link, or large enough to fit snugly between the two links, use one charge; but if it is not, use two separately primed charges.

(6) *Use of the table in making calculations.* Table 3-1 shows the correct weight of TNT necessary to cut steel sections of various dimensions calculated from the formula $P = \frac{3}{8} A$.
In using this table:

(*a*) Measure separately the rectangular sections of members.

(*b*) Find the corresponding charge for each section by using the table.

(c) Total the charges for the sections.

(d) Use the next larger given dimension, if dimensions of sections do not appear in the table.

(7) SOLUTION:
The problem in figure 3-5 may be solved as follows:

Charge for flanges:
width = 5 inches
thickness = ½ inch
Charge from table = 1.0 pounds

Charge for web:
height = 11 inches
thickness = ⅜ inch
Charge from table = 1.6 pounds

Total charge: 2 flanges = 2 x 1.0 = 2.0 pounds
web = 1 x 1.6 = 1.6 pounds
3.6 pounds

Use 4 pounds of TNT.

*b. Formulas for Plastic or Sheet Explosive Charges.* When using plastic explosive (M5A1 or M112) charges or sheet explosive (M118 or M186) charges, which may be cut to fit the target and attached to the surface of the target with little or no air gap, the following formulas, based upon optimum charge configuration and optimum contact with the target, may be used. The following charge calculations are based upon the dimensions

*Table 3-1. TNT Needed To Cut Steel Sections*

| Average thickness of section in inches | Pounds of explosive * for rectangular steel sections of given dimensions | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Height of section in inches | | | | | | | | | | | | | | | | |
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 14 | 16 | 18 | 20 | 22 | 24 |
| ¼ | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1.0 | 1.1 | 1.2 | 1.3 | 1.5 | 1.7 | 1.9 | 2.1 | 2.3 |
| ⅜ | 0.3 | 0.5 | 0.6 | 0.7 | 0.9 | 1.1 | 1.2 | 1.3 | 1.4 | 1.6 | 1.7 | 2.0 | 2.3 | 2.6 | 2.8 | 3.1 | 3.4 |
| ½ | 0.4 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.5 | 1.7 | 1.9 | 2.1 | 2.3 | 2.7 | 3.0 | 3.4 | 3.8 | 4.2 | 4.5 |
| ⅝ | 0.5 | 0.7 | 1.0 | 1.2 | 1.4 | 1.7 | 1.9 | 2.2 | 2.4 | 2.7 | 2.9 | 3.3 | 3.8 | 4.3 | 4.7 | 5.2 | 5.7 |
| ¾ | 0.6 | 0.9 | 1.2 | 1.4 | 1.7 | 2.0 | 2.3 | 2.6 | 2.8 | 3.1 | 3.4 | 4.0 | 4.5 | 5.1 | 5.7 | 6.3 | 6.8 |
| ⅞ | 0.7 | 1.0 | 1.4 | 1.7 | 2.0 | 2.4 | 2.7 | 3.0 | 3.3 | 3.7 | 4.0 | 4.6 | 5.3 | 6.0 | 6.6 | 7.3 | 7.9 |
| 1 | 0.8 | 1.2 | 1.5 | 1.9 | 2.3 | 2.7 | 3.0 | 3.4 | 3.8 | 4.2 | 4.5 | 5.3 | 6.0 | 6.8 | 7.5 | 8.3 | 9.0 |

*TNT
To use:
1. Measure rectangular sections of members separately.
2. Using table, find charge for each section.
3. Add charges for sections to find total charge.
4. If dimensions of sections do not appear on table, use the next larger dimension.

of the target, and with some practice these charges may be calculated, prepared, and placed in less time than the charges calculated by the formulas listed above. These charges may also be prepared in advance for transportation to the site by wrapping them in aluminum foil or heavy paper. The wrapper should be removed when the charge is attached to the target. When preparing these charges the explosive should be cut to the proper dimension, not molded, as molding the explosive will reduce its density thereby decreasing its effectiveness.

(1) *Ribbon charge method.* This charge, if properly calculated and placed, cuts steel with considerably less explosive than standard charges. It is effective on noncircular steel targets up to 3 inches thick (fig 3–7). Although this charge is based upon the use of C4 plastic explosive, sheet

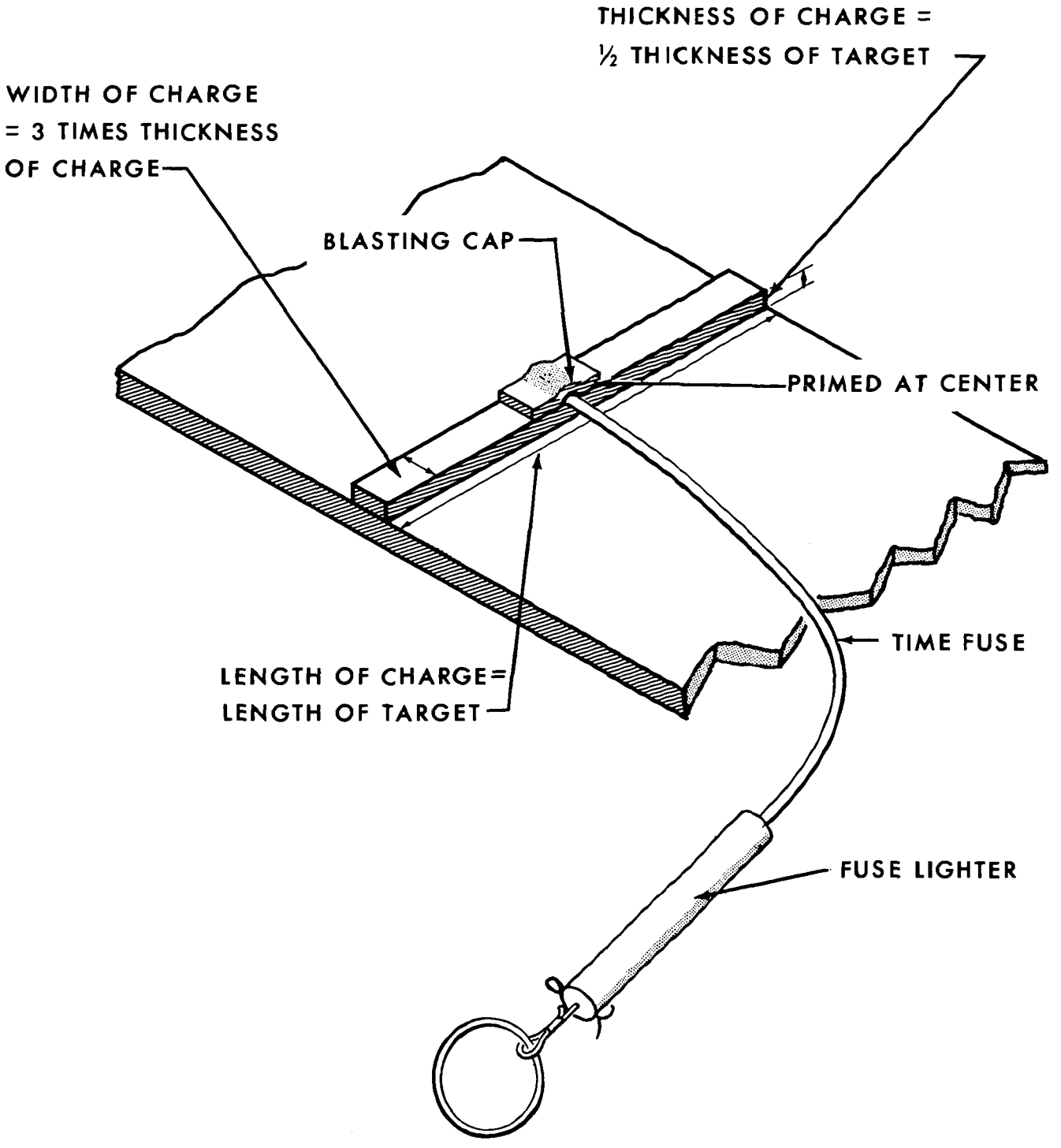



*Figure 3–7. Ribbon charge.*

explosive may be used provided the ¼- by 3- by 12-inch sheets of flexible explosive are used intact and complete charges are at least ½ inch thick.

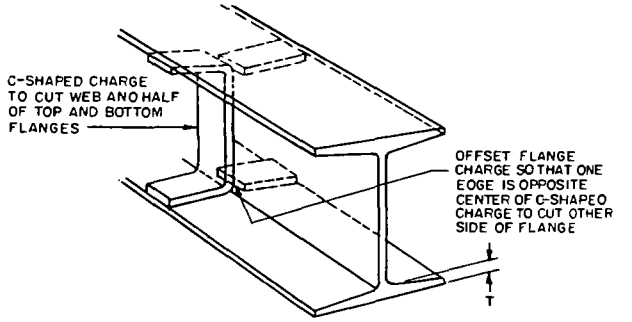
(*a*) *Calculation.* The effectiveness of the explosive depends upon the width and thickness of the explosive. The thickness of the charge is one half the thickness of the steel. The width of the charge is three times the thickness of the charge. The length of the charge should be equal to the length of the desired cut.

(*b*) *Example.* Determine the thickness and width of a ribbon charge for cutting a steel plate 1 inch thick.

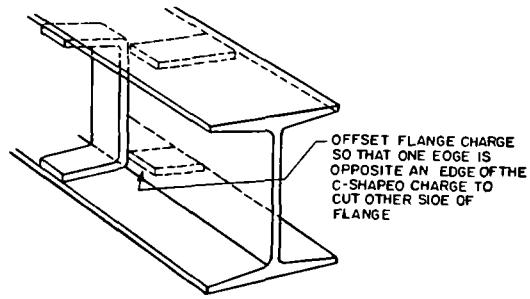
Charge thickness = ½ steel thickness
Charge thickness = ½ (1) = ½ inch
Charge width = 3 times charge thickness

$$\text{Charge width} = 3\ (½) = \frac{3}{2} = 1½ \text{ inches}$$

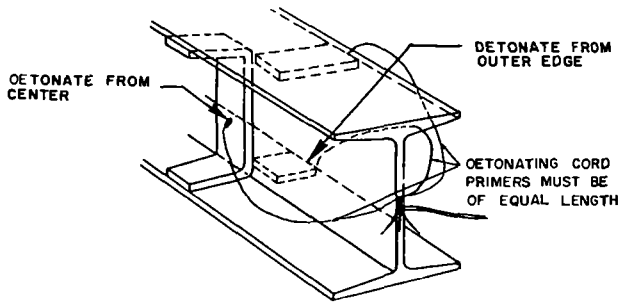
Charge is ½ inch thick and 1½ inches wide.




A. BEAMS LESS THAN 2 IN THICK




B. BEAMS 2 IN THICK OR MORE




C. PRIMING

*Figure 3–8. Placement of ribbon charges on structural steel sections.*

(*c*) *Detonation.* The ribbon charge may be detonated from the center or from either end. It may be necessary when the charge thickness is small (less than ¾ inch) to place extra explosive around or over the blasting cap.

(*d*) *Use of structural steel sections.* The ribbon charge (computed by formula given in (*b*) above) has proven applicable to cutting structural steel sections (fig 3–8).

On wide-flange or I-beams of less than 2 inches of steel thickness, a C-shaped charge is placed on one side to cut the web and half the top and bottom flanges. The other sides of these flanges are cut by two offset ribbon charges, placed so that one edge is opposite the center of the C-shaped charge as shown in A, figure 3–8. For beams with steel thickness of 2 inches and over, the offset charges are placed so that one edge is opposite the edge of the C-shaped charge as shown in B, figure 3–8. For acceptable results, the charges must be detonated at the *same instant.* This is accomplished by priming the charges with three exactly *equal lengths* of detonating cord with blasting caps attached and placed in the charges as shown in C, figure 3–8. The detonating cord primer may be initiated by an electric or nonelectric system. Simultaneous detonation may also be accomplished with M6 electric blasting caps wired in series in the same circuit.

(2) *Cross fracture method (saddle charge) for cutting milled steel bars.* This method of steel cutting utilizes the destructive effect of the end split or cross fracture formed in steel at the end of a charge opposite the end where detonation was initiated. This technique may be used on round, square, or rectangular milled steel bars up to 8 inches square or 8 inches in diameter. The cross fracture method uses a charge cut in the shape of a triangle and is called a *saddle charge* (fig 3–9).

(*a*) *Calculation.* The dimensions of the saddle charge are computed from the dimensions of the target as follows:

Thickness of charge = 1 inch (thickness of M112 block of plastic explosive).
Base of charge = ½ circumference of target.
Long axis of charge = Circumference of target.

(*b*) *Example.* Determine the dimensions of a charge for cutting a shaft 18 inches in circumference (may be measured with a string).

Thickness = 1 inch
Base = ½ × 18 = 9 inches
Long axis = 18 inches

Charge is 9 inches at base, 18 inches at long axis, and 1 inch thick.

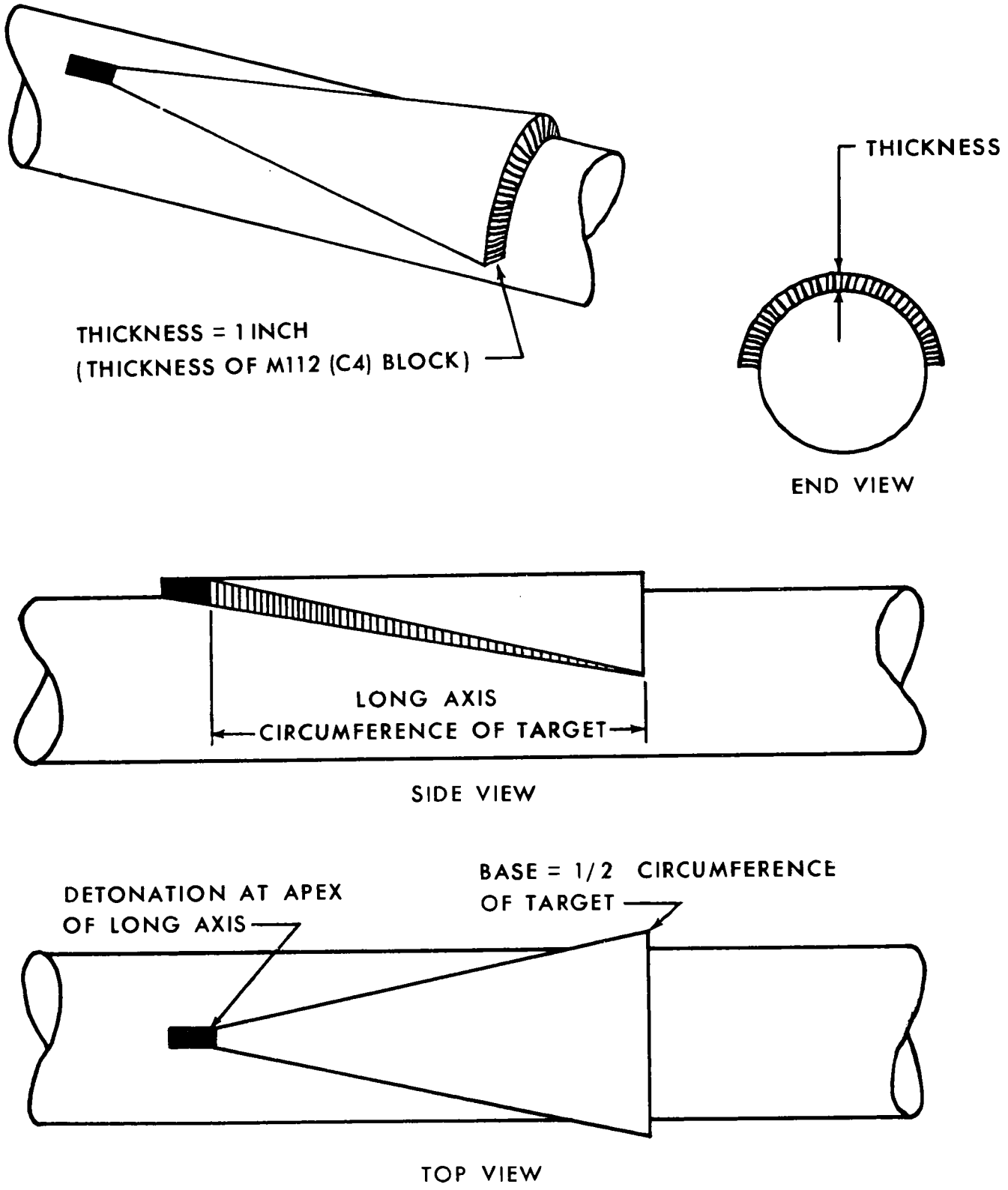



*Figure 3–9. Cross fracture method—saddle charge.*

(*c*) *Detonation.* Detonation of the saddle charge is by the placement of a military electric or nonelectric blasting cap at the apex of the long axis.

(*d*) *Placement.* The long axis of the saddle charge should be parallel with the long axis of the target. The charge should be cut to the correct shape and dimensions and then molded around the target, taking care to insure that the charge is in intimate contact with the target. This may be accomplished by taping the charge to the target.

(3) *Stress wave method (Diamond charge).* This method of steel cutting utilizes the destructive effect of tensile fractures induced through the interaction of two colliding shock wave fronts from an explosive charge simultaneously detonated at opposite ends. This technique may be used on high carbon steel or steel alloy bars either circular or square in cross section. The stress wave method uses a charge cut in the shape of a diamond, and thus called a diamond charge (fig 3–10).

(*a*) *Calculation.* The dimensions of the diamond charge are computed from the dimensions of the target as follows:

Thickness of charge = 1 inch (thickness of M112 block of plastic explosive).
Long axis of charge = Circumference of target.
Short axis of charge = ½ the circumference of the target.

(*b*) *Example.* Determine the size of a charge for cutting a steel alloy shaft 15 inches in circumference.

Thickness = 1 inch
Long axis = 15 inches
Short axis = ½ × 15 = 7½ inches

Charge is 15 inches at long axis, 7 1/2 inches at short axis, and 1 inch thick.

(*c*) *Detonation.* The detonation of diamond charge must be done *simultaneously* from both short axis ends. This may be done by priming with two pieces of detonating cord of the *same length* with nonelectric blasting caps crimped to the ends. The detonating cord primers may be detonated with an electric or nonelectric blasting cap. Simultaneous detonation may also be accomplished with M6 electric blasting caps wired in series in the same circuit.

(*d*) *Placement.* Wrap the explosive completely around the target so that the ends of the long axis touch. It may be necessary to slightly increase the dimensions of the charge so this may be accomplished. If necessary to insure complete contact with the target, tape the charge to the target.

## 3–9. Charge Placement

*a. Steel Sections.* The size and type of a steel section determine the placement of the explosive charge. Some elongated sections may be cut by placing the explosive on one side of the section completely along the proposed line of rupture. In some steel trusses in which the individual members are fabricated from two or more primary sections, such as angle irons or bars separated by spacer washers or gusset plates, the charge must be placed with the opposing portions of the charge offset the same distance as the thickness of the section being cut to produce a shearing action (para 3–8*b*(1)(*d*)). Heavier I-beams, wide flange beams, and columns may also require auxiliary charges placed on the outside of the flanges. Care must be taken to insure that opposing charges are never directly opposite each other, otherwise they tend to neutralize the explosive effect.

*b. Rods, Chains, and Cables.* Block explosive, often difficult to emplace, is not recommended for cutting steel rods, chains, and cables if plastic explosive is available.

*c. Steel Members and Railroad Rails.* Charge placement for cutting these are found in figures 3–11 and 4–39.

*d. Built-up Members.* Built-up members frequently have an irregular shape, which makes it difficult to obtain a close contact between the explosive charge and all of the surface. If it is impractical to distribute the charge properly to obtain close contact, the amount of explosive should be increased.

*e. Irregular Steel Shapes.* Composition C4 is a good explosive for cutting irregular steel shapes because it is easily molded or pressed into place to give maximum contact. In the case of the M5A1 block charge, which uses C4, a light coating of adhesive compound or automotive grease (GAA) applied to the steel surface will help hold the explosive on the target. The M112 block, which also uses C4, and the M118 sheet explosive have an adhesive coating on one side, which makes placement easier.

*f. Securing Explosives in Place.* All explosives except adhesive types must be tied, taped, wedged in place unless they rest on horizontal surfaces and are not in danger of being jarred out of place.

*g. Precautions.* In cutting steel, the charge should be placed on the same side as the firing party, as explosive charges throw steel fragments (missiles) long distance at high velocities.

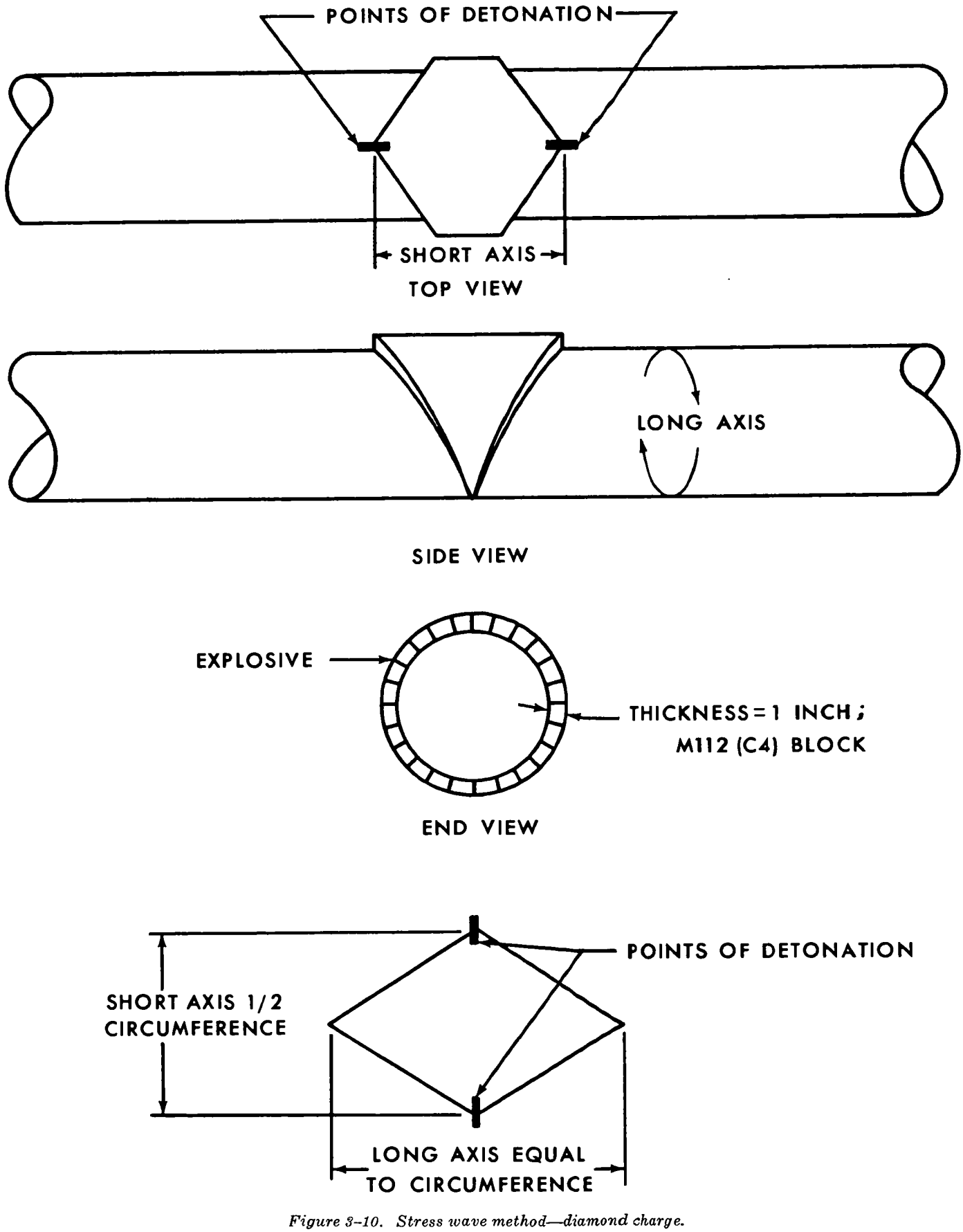



*Figure 3–10. Stress wave method—diamond charge.*

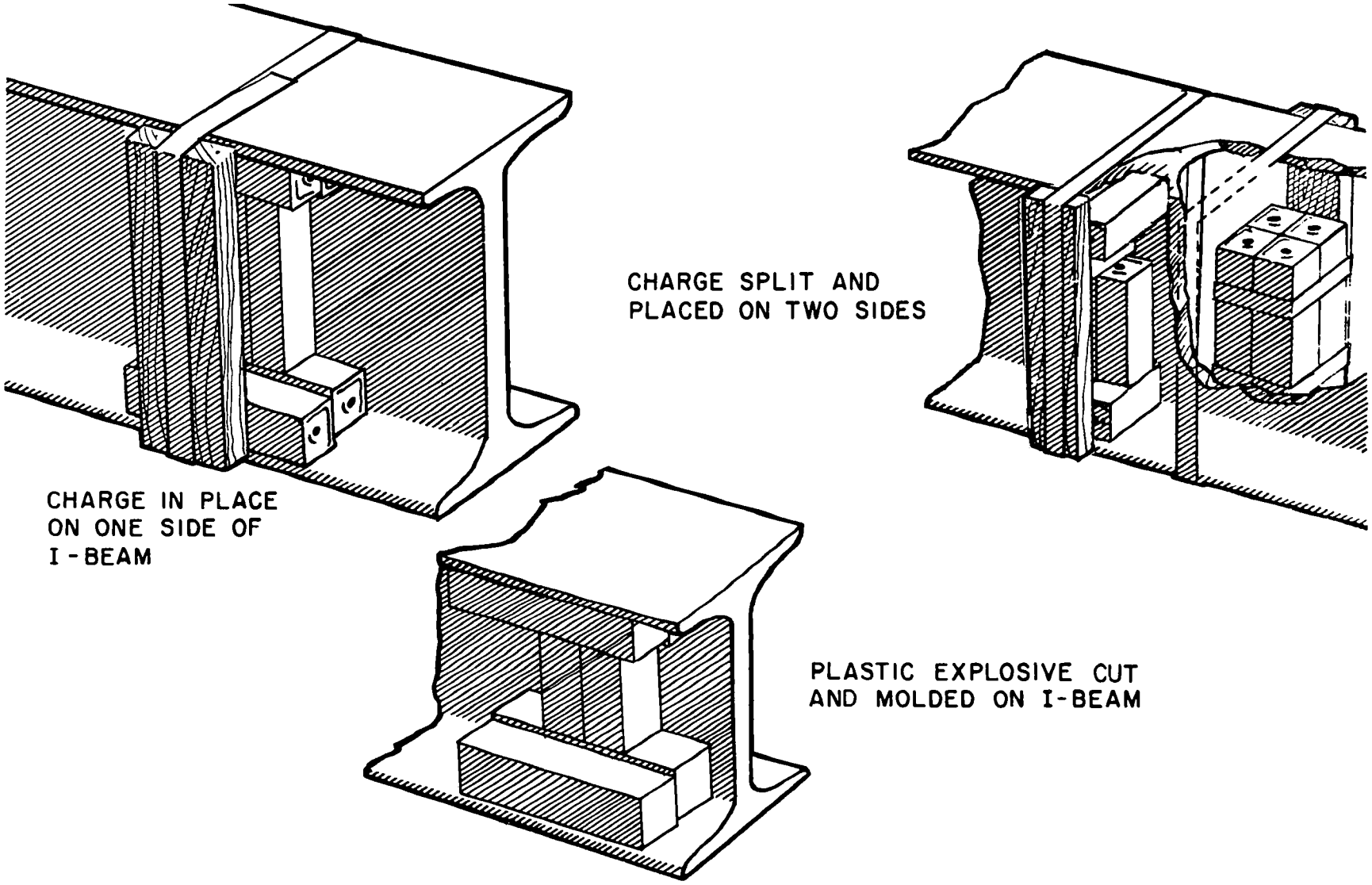



*Figure 3–11. Placement of charges on steel members.*

## Section IV. PRESSURE CHARGES

### 3–10. Size of Charge

The pressure charge is used for the demolition of reinforced concrete T-beam bridge superstructures. Since it requires the use of more explosives than breaching charges, with comparable placement, it has been replaced by the breaching charge (para 3–12—3–14).

*a. Formula for Tamped Pressure Charges.* The amount of TNT required for a tamped pressure charge is calculated by the formula below. If explosive other than TNT is used, the calculated value must be divided by the relative effectiveness factor.

$P = 3H'T$

$P$ = pounds of TNT required for each beam (stringer)
$H$ = height of beam (including thickness of roadway) in feet
$T$ = thickness of beam in feet

*b. Formula for Untamped Pressure Charges.* The value calculated for $P$ by the above formula is increased by one-third if the pressure charge is not tamped to a minimum of 10 inches ($P = 4H^2T$).

### 3–11. Charge Placement and Tamping

*a. Placement.* The correct amount of explosive is placed on the roadway over the centerline of each stringer (fig 3–12) and alined between the ends of the span. If a curb or side rail prevents placing the charge directly above the outside stringer, it is placed against the curb or side rail. This does not require an increase in the size of the explosive charge (*See also* para 4–22).

*b. Tamping.* Pressure charges should be tamped whenever possible. Effective tamping requires a minimum of 10 inches of material. All charges are primed to fire simultaneously.

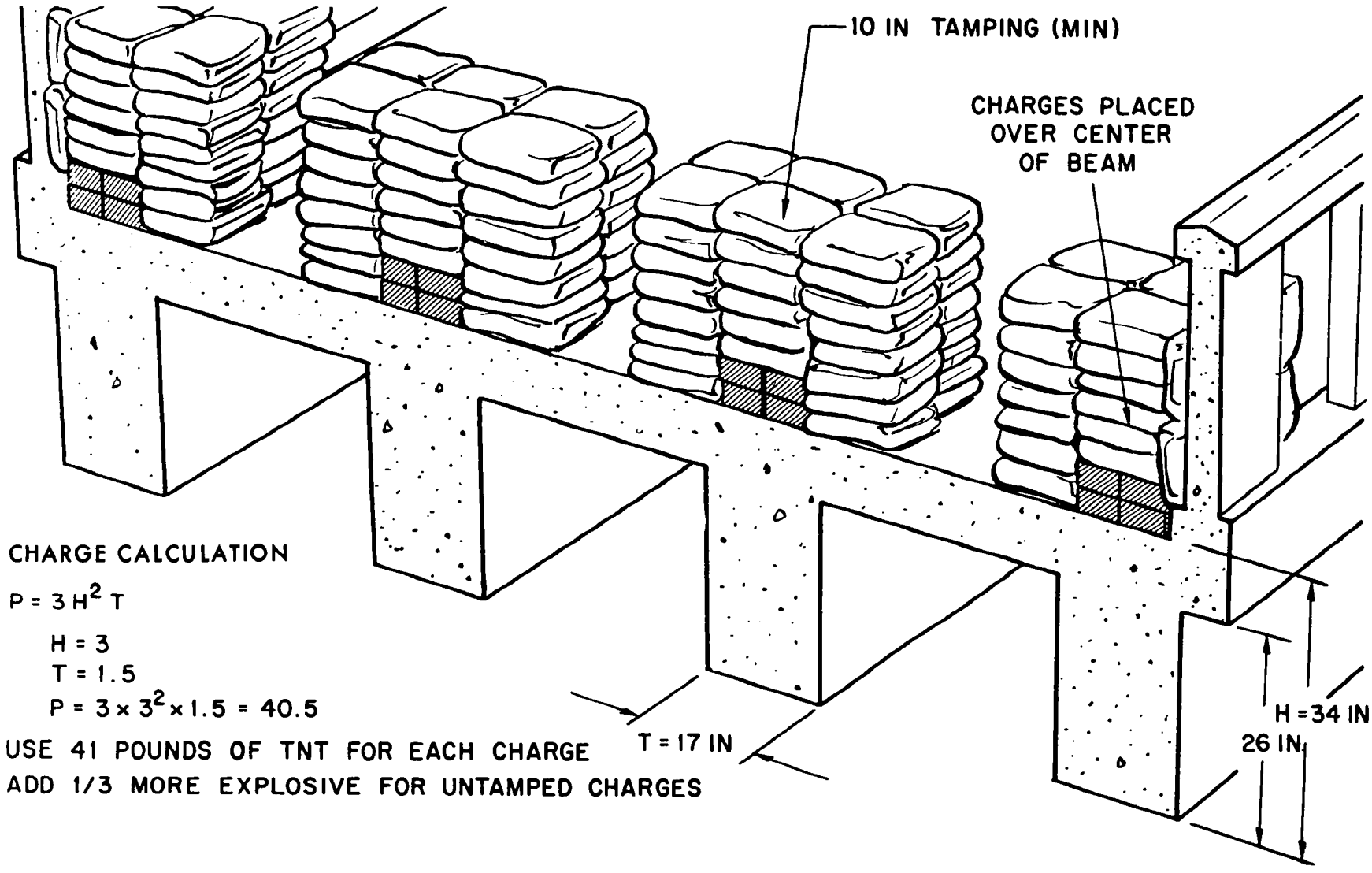



*Figure 3–12. Calculation and placement of pressure charges.*

## Section V. BREACHING CHARGES

### 3–12. Critical Factors and Computation

Breaching charges are applied chiefly to the destruction of concrete slab bridges, bridge beams, bridge piers, bridge abutments, and permanent field fortifications. The size and shape, placement, and tamping or confinement of the breaching charge are critical factors—the size and confinement of the explosive being relatively more important because of strength and bulk of the material to be breached. High explosive breaching charges detonated in or against a target must produce and transmit enough energy to the target to crater and spall the material. The metal reinforcing bars in reinforced concrete are not cut by breaching charges. If it is necessary to remove or cut the reinforcement, the necessary steel cutting formula is used after the concrete is breached.

*a. Calculation Formula.* The size of a charge required to breach concrete, masonry, rock or similar material is calculated by the formula below. By proper adjustment of the *P*-value, the charge size for any explosive may be readily determined.

$P = R^3 KC$ where;
$P$ = pounds of TNT required,
$R$ = breaching radius (*b* below),
$K$ = material factor, given in table 3–4, which reflects the strength, hardness and mass of the material to be demolished (*c* below),
$C$ = a tamping factor, given in figure 3–13, which depends on the location and tamping of the charge (*d* below)

*b. Breaching Radius R.* The breaching radius $R$ is the distance in feet from an explosive in which all material is displaced or destroyed. The breaching radius for external charges is the thickness of the mass to be breached. The breaching radius for internal charges is one-half the thickness of the mass to be breached if the charge is placed midway into the mass. If holes are drilled less than halfway into the mass, the breaching radius becomes the longer distance from center of the charge to the outside of the mass. For example, if a 4-foot wall is to be breached by an internal charge placed 1 foot into the wall, the breaching radius is 3 feet. If it is to be breached by a centered internal charge, the breaching radius is 2 feet. The breaching radius is 4 feet if an external charge is used. Values of $R$ are rounded off to the next highest ½-foot for external charges, and to the next highest ¼-foot for internal charges.

*c. Material Factor K.* K is the factor that reflects the strength and hardness of the material to be breached. Table 3–2, gives values for the factor $K$ for various types and thicknesses of material. If the type of material in the object is in doubt, it is always assumed to be of the stronger type. Concrete is assumed to be reinforced, unless it is known not to be.

*d. Tamping Factor C.* The value of the tamping factor $C$ depends on the location and the tamping of the charge. Figure 3–13 shows typical methods for placing charges and gives values of $C$ to be used in the breaching formula with both tamped and untamped charges. In selecting a value of $C$ from figure 3–13, a charge tamped with a solid material such as sand or earth or tamped by water is not considered fully tamped unless it is covered to a depth equal to or greater than the breaching radius.

*Table 3–2. Values of K (Material Factor) For Breaching Charges.*

| Material | Breaching radius | K |
|---|---|---|
| Ordinary earth | All values | 0.07 |
| Poor masonry, shale, hardpan: Good timber and earth construction | Less than 5 ft | 0.32 |
| | 5 ft or more | 0.29 |
| Good masonry ordinary concrete rock | 1 ft or less | 0.88 |
| | 1.5–2.5 ft | 0.48 |
| | 3.0–4.5 ft | 0.40 |
| | 5.0–6.5 ft | 0.32 |
| | 7 ft or more | 0.27 |
| Dense concrete first-class masonry | 1 ft or less | 1.14 |
| | 1.5–2.5 ft | 0.62 |
| | 3.0–4.5 ft | 0.52 |
| | 5.0–6.5 ft | 0.41 |
| | 7 ft or more | 0.35 |
| Reinforced concrete (concrete only: Will not cut reinforcing steel) | 1 ft or less | 1.76 |
| | 1.5–2.5 ft | 0.96 |
| | 3.0–4.5 ft | 0.80 |
| | 5.0–6.5 ft | 0.63 |
| | 7 ft or more | 0.54 |

*e. Use of Figure in Making Calculations.* Figure 3–14 gives the amount of TNT required to breach reinforced concrete targets. The amounts of TNT in the table were calculated from the formula $P = R^3KC$. To use the figure:

(1) Measure thickness of concrete.

(2) Decide how the charge will be placed against the target. Compare the method of placement with the diagrams at the top of the figure. If there is any question as to which column to use, always use the column that will give the greater amount of explosive.

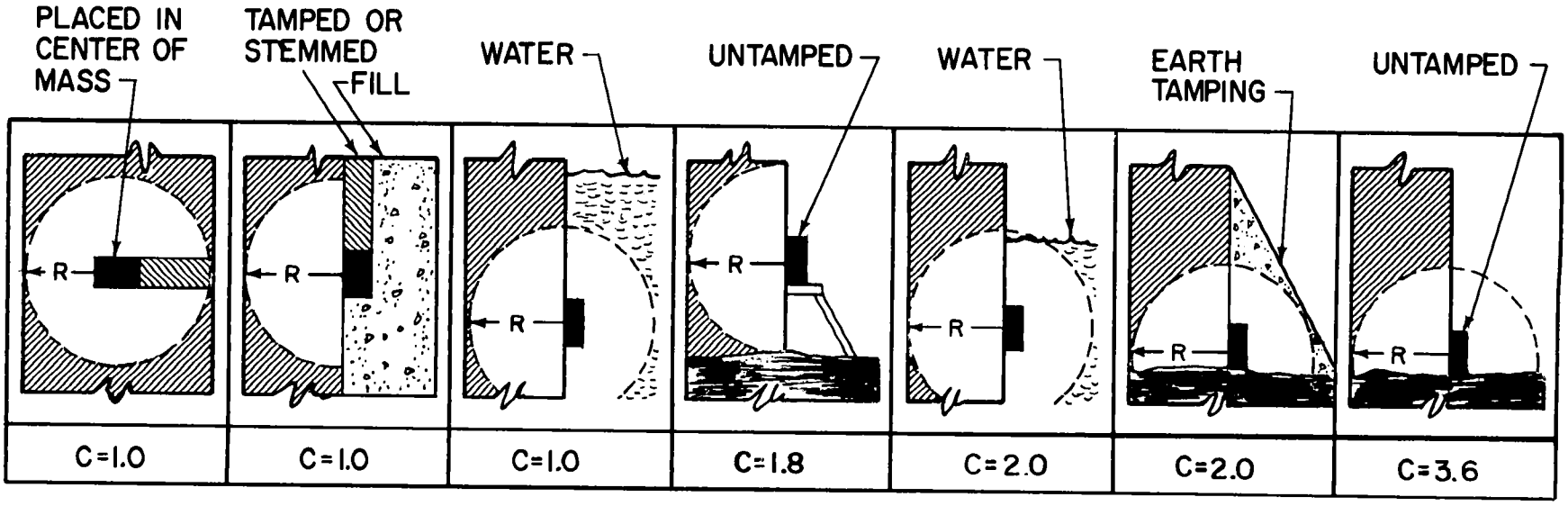



*Figure 3–13. Values of C(tamping factor) for breaching charges.*

## BREACHING CHARGES FOR REINFORCED CONCRETE

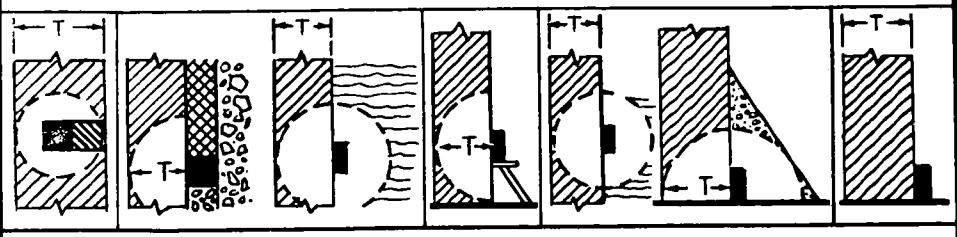
| THICKNESS OF CONCRETE | METHODS OF PLACEMENT | | | | | DISTANCE BETWEEN CHARGES | |
|---|---|---|---|---|---|---|---|
| |  | | | | | INTERNAL | EXTERNAL |
| FEET | POUNDS OF TNT | | | | | FEET | FEET |
| 2 | 2 | 8 | 14 | 16 | 28 | 2 | 4 |
| 2½ | 2 | 15 | 27 | 30 | 54 | 2½ | 5 |
| 3 | 4 | 22 | 39 | 44 | 78 | 3 | 6 |
| 3½ | 6 | 35 | 62 | 69 | 124 | 3½ | 7 |
| 4 | 8 | 52 | 93 | 103 | 185 | 4 | 8 |
| 4½ | 11 | 73 | 132 | 146 | 263 | 4½ | 9 |
| 5 | 15 | 79 | 142 | 158 | 284 | 5 | 10 |
| 5½ | 20 | 105 | 189 | 210 | 378 | 5½ | 11 |
| 6 | 22 | 136 | 245 | 273 | 490 | 6 | 12 |
| 6½ | 28 | 173 | 312 | 346 | 623 | 6½ | 13 |
| 7 | 35 | 186 | 334 | 371 | 667 | 7 | 14 |
| 7½ | 43 | 228 | 410 | 456 | 821 | 7½ | 15 |
| 8 | 52 | 277 | 498 | 553 | 996 | 8 | 16 |

*Figure 3–14. Breaching charges for reinforced concrete.*

(3) For explosives other than TNT, use the relative effectiveness factor (table 1–2).

*f. Example.* Using figure 3–14, calculate the amount of TNT required to breach a reinforced concrete wall 7 feet thick with an untamped charge placed at a distance *R* above the ground. From the figure the required amount of TNT is 334 pounds.

*g. Using Figure for Material Other Than Reinforced Concrete.* The values given in figure 3–13 may be used to calculate breaching charges for obstacles of material other than reinforced concrete by multiplying the value obtained from figure 3–14 by the proper conversion factor given in table 3–3. To use the table—

(1) Determine the type of material in the object. If in doubt, assume the material to be of the stronger type, e.g. assume concrete to be reinforced, unless known otherwise.

(2) Using figure 3–14, determine the amount of explosive that would be required if the object were made of reinforced concrete.

(3) Using table 3–3, determine the appropriate conversion factor.

(4) Multiply the number of pounds of explosive by the conversion factor.

*Table 3–3. Conversation Factors for Material other than Reinforced Concrete*

| Earth | Ordinary masonry, hardpan, shale, ordinary concrete, rock, good timber and earth construction | Dense concrete, first-class masonry |
|---|---|---|
| 0.1 | 0.5 | 0.7 |

*h. Example.* Using figure 3–14 and table 3–3

determine the amount of TNT required to breach an ordinary masonry pier 4½ feet thick with an untamped charge placed 4 feet below the waterline. If the pier were made of reinforced concrete, 146 pounds of TNT would be required to breach it (fig 3–14). The conversion factor (table 3–3) is 0.5. Therefore 146 × 0.5 = 73 pounds of TNT are required to breach the pier.

## 3–13. Placement and Number of Charges

*a. Placement.* In the demolition of piers and walls, the positions for the placement of explosive charges are rather limited. Unless a demolition chamber is available, the charge (or charges) may be placed against one face of the target either at ground level, somewhat above ground level, or beneath the surface. A charge placed above ground level is more effective than one placed directly on the ground. When several charges are required to destroy a pier, slab, or wall and elevated charges are desired, they are distributed equally at no less than one breaching radius high from the base of the object to be demolished. In this manner, the best use is obtained from the shock waves of the blast. *Breaching charges should be placed so that there is a free reflection surface on the opposite side of the target.* This free reflection surface is necessary for spalling to occur (see para 3–2). All charges are thoroughly tamped with damp soil or filled sandbags if time permits. (Tamping must be equal to or greater than the breaching radius.) For piers, slabs, or walls partially submerged in water, charges are placed equal to or greater than the breaching radius below the waterline (fig 3–13).

*b. Charge Configuration.* In order to transmit the maximum destructive shock into the target, the explosive charge should be placed in the shape of a flat square with the flat side to the target. The thickness of the charge is dependent upon the amount of explosive and is given in table 3–4.

*Table 3–4. Thickness of Breaching Charges* *

| Amount of explosive | Thickness of charge |
|---|---|
| Less than 5 lbs | 1 inch |
| 5 lbs to less than 40 lbs | 2 inches |
| 40 lbs to less than 300 lbs | 4 inches |
| 300 lbs of more | 8 inches |

* These are approximate values.

*c. Number of Charges.* The number of charges required to demolish a pier, slab, or wall is calculated by the formula:

$$N = \frac{W}{2R}$$ where,

$N$ = number of charges,
$W$ = width of pier, slab, or wall, in feet,
$R$ = breaching radius in feet (para 3–12*b*).
2 = constant.

If the calculated value of $N$ is less than 1¼, use one charge; if it is 1¼ to less than 2½, use 2 charges; if it is 2½ or more, round off to nearest whole number. In breaching concrete beam bridges, each beam is breached individually.

## 3–14. Opposed (Counterforce) Charge

This special breaching technique is effective against comparatively small cubical or columnar concrete and masonry objects 4 feet or less in thickness and width. It is not effective against piers or long obstacles. The obstacle must also have at least three free faces or be free standing. If constructed of plastic explosive properly placed and detonated, counterforce charges produce excellent results with a relatively small amount of explosive. Their effectiveness results from the simultaneous detonation of two charges placed directly opposite each other and as near the center of the target as possible (fig 3–15).

*a. Charge Calculation.* The size is computed from the diameter or thickness of the target in feet, as—

The amount of explosive = 1½ × the thickness of the target in feet (1½ pounds per foot).

Fractional measurements are rounded off to the next higher foot prior to multiplication. For example, a concrete target measuring 3 feet 9 inches thick requires 1 1/2 × 4 = 6 pounds of plastic explosive (composition C4).

*b. Preparation and Emplacement.* Divide the calculated amount of explosive in half to make two identical charges. The two charges *must* be placed diametrically opposite each other. This requires accessibility to both sides of the target so that the charges may be placed flush against the respective target sides.

*c. Priming.* The simultaneous explosion of both charges is mandatory for optimum results. Crimp nonelectric blasting caps to equal lengths of detonating cord. Prime both charges at the center rear point; then form a V with the free ends of the detonating cord and attach an electric or nonelectric means of firing. Simultaneous detonation may also be accomplished with M6 electric blasting caps wired in series in the same circuit.

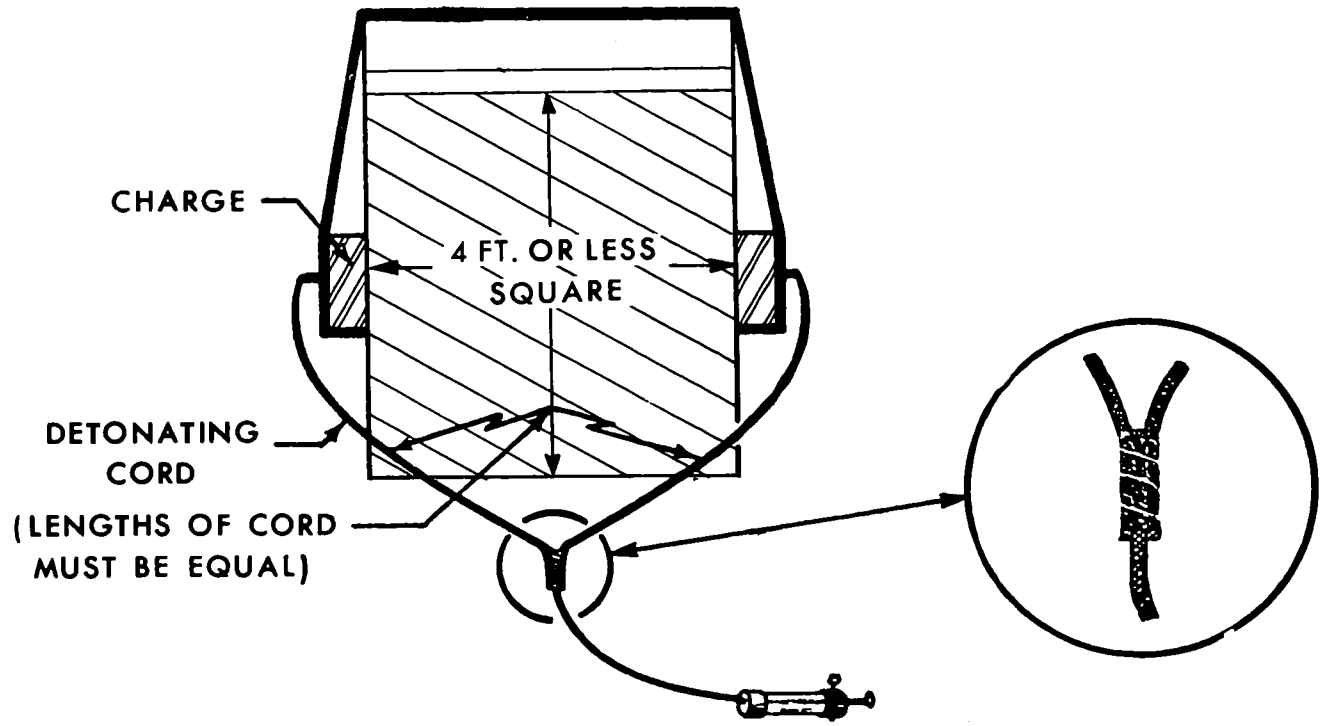



*Figure 3–15. Opposed Charge.*

## Section VI. CRATERING AND DITCHING CHARGES

### 3–15. Critical Factors

*a. Size.* Road craters, to be effective obstacles, must be too wide for spanning by track-laying vehicles and too deep and steep sided for any vehicle to pass through them. Blasted road craters will not stop modern tanks indefinitely, because repeated attempts by the tank to traverse the crater will pull loose soil from the slopes of the crater into the bottom reducing both the depth of the crater and angle of the slopes. Road craters are considered effective antitank obstacles if the tank requires three or more passes to traverse the crater, thereby providing sufficient time for antitank weapons to stop the tank. Road craters must also be large enough to tie into natural or manmade obstacles at each end. The effectiveness of blasted road craters may be improved by placing log hurdles on either side, by digging the face on the friendly side nearly vertical, by mining the site with antitank and antipersonnel mines.

*b. Explosive.* All military explosives may be used for blasting antitank craters. A special 40-pound cratering charge, ammonium nitrate, issued in a waterproof metal container, is used when available (para 1–4).

*c. Size and Placement of Charge.* In deliberate cratering, holes are bored to specific depths and spaced according to computation by formula, as described below. In ditching, test shots are made and the diameter and depth are increased as required.

*d. Confinement of Charge.* Charges at cratering sites and antitank ditching sites are placed in boreholes and properly stemmed. Those at culvert sites are tamped with sandbags.

*e. Breaching Hard-Surfaced Pavements for Cratering Charges.* Hard-surfaced pavement of roads and airfields is breached so that holes may be dug for cratering charges. This is done effectively by exploding tamped charges on the pavement surface. A 1-pound charge of explosive is used for each 2 inches of pavement thickness. It is tamped with material twice as thick as the pavement. The pavement may also be breached by charges placed in boreholes drilled or blasted through it. (A shaped charge readily blasts a small diameter borehole through the pavement and into the subgrade.) Concrete should not be breached at an expansion joint, because the concrete will shatter irregularly.

*f. Boreholes for Cratering Charges.* Boreholes for cratering charges may be dug by using motorized post hole augers or hand post hole augers

or diggers. Boreholes may also be made by use of the earth rod kit (para 1–41) or by a mechanically driven pin, widened with a detonating cord wick (para 3–27).

*g. Blasting Boreholes with Shaped Charges.* Standard shaped charges may be used to blast boreholes in both paved and unpaved surfaces for rapid road cratering with explosives. The 15-pound M2A4 shaped charge detonated at 3½ foot standoff and the 40-pound M3A1 shaped charge detonated at 5-foot standoff will blast boreholes of up to 9-foot open depths with 7-inch and larger diameters in both reinforced concrete pavements and graval surfaced roads. For maximum effectiveness, M3A1 shaped charges should be used to blast boreholes in thick, reinforced concrete pavements laid on dense high-strength base courses. The M2A4 shaped charges may be used effectively to blast cratering charge boreholes in reinforced concrete pavement of less than 6-inch thickness laid on thin base courses or to blast boreholes in unpaved roads. Most any kind of military explosive, including the cratering charges, can be loaded directly into boreholes made by the M3A1 and the M2A4 shaped charges. Shaped charges do not always produce open boreholes capable of being loaded directly with 7-inch diameter cratering charges without removal of some earth or widening of narrow areas. Many boreholes having narrow diameters but great depth can be widened simply by knocking material from the constricted areas with a pole or rod or by breaking off the shattered surface concrete with a pick or crowbar. For road cratering on asphalt or concrete surfaced roadways, blasting the boreholes with shaped charges will expedite the cratering task by eliminating the requirement for first breaching the pavement with explosive charges (table 3–5).

*Table 3–5. Size of Boreholes Made by Shaped Charges*

| Material | | M2A4 shaped charge | M3A1 shaped charge |
|---|---|---|---|
| Armor Plate | Penetration | 12 inch | At least 20 inches |
| | Average diameter of hole | 1½ inch | 2½ inch |
| Reinforced Concrete | Maximum wall thickness that can be perforated. | 36 inch | 60 inch |
| | Depth of penetration in thick walls | 30 inch | 60 inch |
| | Average diameter of hole | 2¾ inch | 3½ inch |
| | Minimum diameter of hole | 2 inch | 2 inch |
| 10-inch concrete pavement with 21-inch rock base course. | Optimum standoff | 42 inch | 60 inch |
| | Minimum depth of penetration | 44 inch | 71 inch |
| | Maximum depth of penetration | 91 inch | 109 inch |
| | Minimum diameter of hole | 1¾ inch | 6¾ inch |
| 3-inch concrete pavement with 24-inch rock base course. | Optimum standoff | 42 inch | |
| | Minimum depth of penetration | 38 inch | |
| | Maximum depth of penetration | 90 inch | |
| | Minimum diameter of hole | 3¾ inch | |
| Permafrost | Depth of hole with 30 inch standoff | 72 inch | |
| | Depth of hole with 42 inch standoff | 60 inch | |
| | Diameter of hole with 30 inch standoff | 6 inch to 1½ inch | |
| | Depth of hole with 50 inch standoff | | 72 inch |
| | Diameter of hole with 50 inch standoff | | 8 inch to 5 inch |
| | Diameter of hole with normal standoff | 26–30 inch to 4 inch | 26–30 inch to 7 inch |
| Ice | Depth with 42 inch standoff | 7 feet | 12 feet |
| | Diameter with 42 inch standoff | 3½ inch | 6 inch |
| Soil | Depth with 30 inch standoff | 7 feet | |
| | Diameter with 30 inch standoff | 7 inch | |
| | Depth with 48 inch standoff | | 7 feet |
| | Diameter with 48 inch standoff | | 14½ inches |

## 3–16. Hasty Road Crater

This method (fig. 3–16) takes the least amount of time for construction, based upon number and depth of boreholes, but produces the least effective barrier because of its depth and shape. The method described below forms a V-shaped crater, about 6 to 7 feet deep and 20 to 25 feet wide extending about 8 feet beyond each end crater. The sides have slopes of 25° to 35°. Modern U.S. combat tanks (the M48 and M60) require an average of four passes to traverse hasty road craters. Craters formed by boreholes less than 5 feet deep and loaded with charges less than 50 pounds are ineffective against tanks. The following hasty cratering method has proved satisfactory:

*a.* Dig all boreholes to the same depth; at least 6 feet. Space the holes 5 feet apart center-to-center across the road. The formula for the computation of the number of holes is: $N = \frac{L - 16}{5} + 1$, where $L$ = length of crater in feet measured across the roadway. Any fractional number of holes is rounded off to the next highest number.

*b.* Load the boreholes with 10 pounds of explosive per foot of depth.

*c.* Prime all charges with detonating cord and connect them to fire simultaneously. Under ground charges should always be primed with detonating cord branch lines. A dual firing system should be used.

*d.* If the standard cratering charge is used, place a 1-pound priming charge on the side of the charge for dual priming. For hasty cratering, if standard cratering charges are used, each charge must be supplemented with 10 pounds of additional explosive to total 50 pounds of explosive per borehold.

*Note. Each cratering charge must be carefully inspected for possible water damage prior to emplacement.*

*e.* Stem all boreholes with suitable material.

## 3–17. Deliberate Road Crater

This cratering method (fig 3–17) produces road craters that are more effective than those resulting from the hasty method as they require an average of eight passes to be crossed by modern U.S. tanks. The crater produced is V-shaped, approximately 7 feet deep, 25 feet wide, with side slopes about 30° to 37°. The crater extends about 8 feet beyond the end holes. The method of placing charges is as follows:

*a.* Bore the holes 5 feet apart, center-to-center, in a line across the roadway. The end holes are 7 feet deep and the others are alternately 5 feet and 7 feet deep. The formula for the computation of the number of holes is:

$N = \frac{L-16}{5} + 1$

$L$ = length of crater in feet measured across roadway.

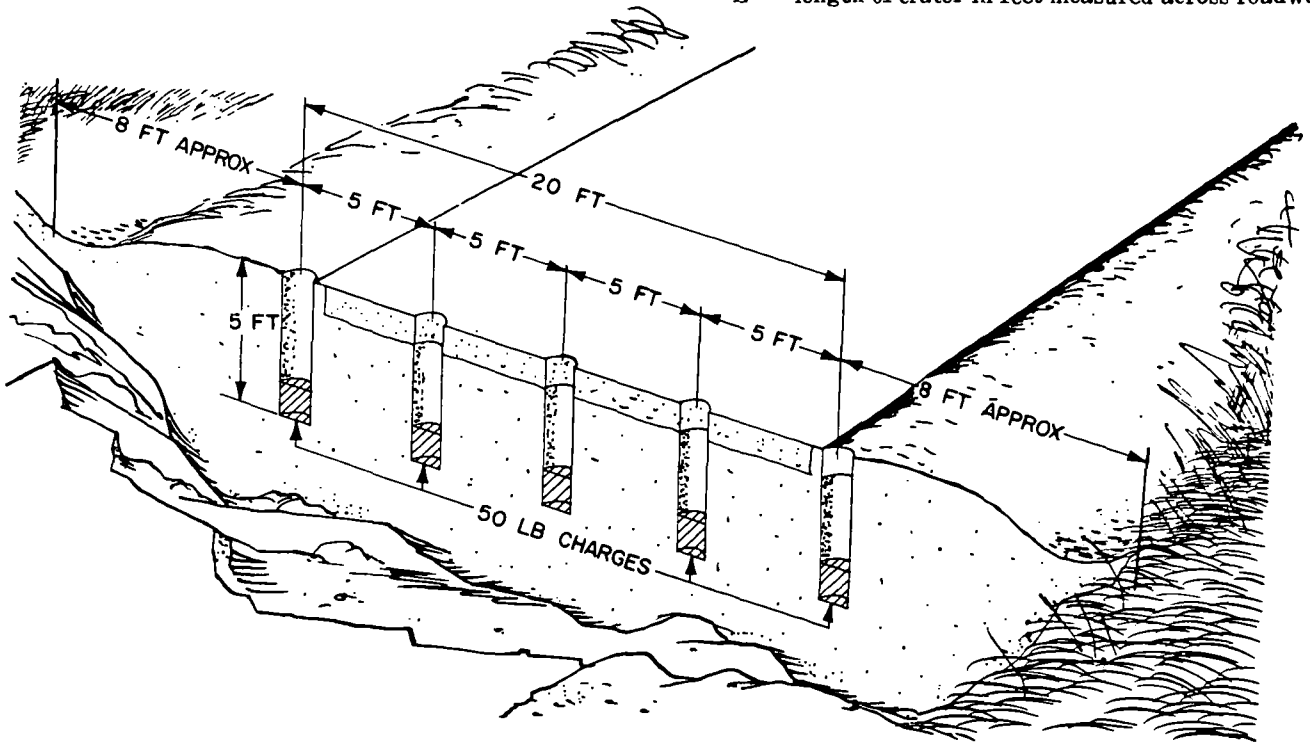



*Figure 3–16. Charge placement for hasty road crater.*

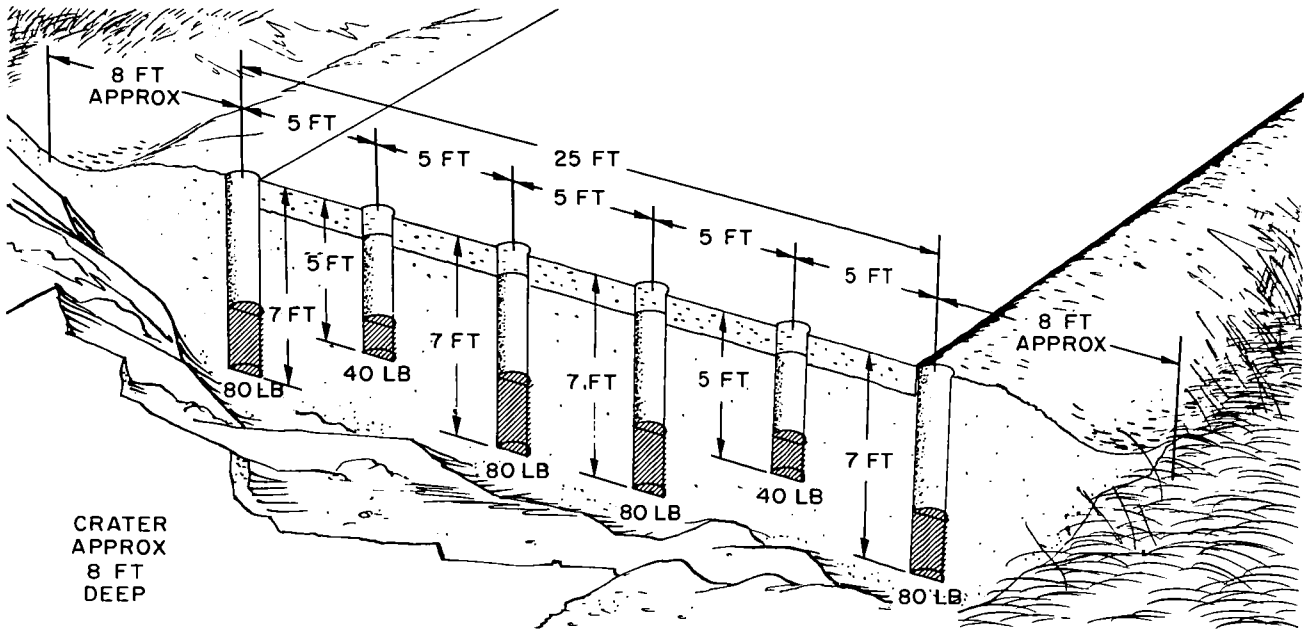



*Figure 3–17. Charge placement for deliberate road crater.*

Any fractional number of holes is rounded off to the next highest number. Two 5-foot holes must not be made next to each other. If they are so calculated, one of them must be a 7-foot hole. The resulting two adjacent 7-foot holes may be placed anywhere along the line.

*b.* Place 80 pounds of explosive in the 7-foot holes and 40 pounds of explosive in the 5-foot holes.

*c.* Prime the charges as for hasty cratering. Dual priming of the 7-foot holes may be accomplished by independent priming of each of the two cratering charges, if used.

*d.* Stem all holes with suitable material.

## 3–18. Relieved Face Road Crater

This cratering method (fig 3–18) produces road craters that are more effective obstacles to modern tanks than the standard V-shaped craters. This technique produces a trapezoidal-shaped crater about 7 feet deep and 25 to 30 feet wide with unequal side slopes. In compact soil, such as clay, the relieved face cratering method will provide an obstacle shaped as shown in A, figure 3–18. The side nearest the enemy slopes at about 25° from the road surface to the bottom while that on the opposite or friendly side is about 30° to 40° steep. The exact shape, however, depends on the type of soil found in the area of operations. The procedure is as follows:

*a.* On dirt or gravel surfaced roads, drill two rows of boreholes 8 feet apart, spacing the boreholes on 7-foot centers. On hard surfaced roads, drill the two rows 12 feet apart. The number of charges for the friendly side row can be calculated by the formula $N = \frac{L-10}{7} + 1$, where $L$ = length of crater in feet measured across the width of the road. Any fractional number of holes should be rounded off to the next highest number. Stagger the boreholes in the row on the enemy side in relationship to the other row, as shown in B, figure 3–18. This row will always contain one less borehole than the other row.

*b.* Make the boreholes on the friendly side 5 feet deep and load with 40 pounds of explosive, and those on the enemy side 4 feet deep and load with 30 pounds of explosive.

*c.* Prime the charges in each row separately for simultaneous detonation. There should be a delay of detonation of ½ to 1½ seconds between rows, the row on the enemy side being detonated first. Best results will be obtained if the charges on the friendly side are fired while the earth moved in the first row is still in the air. Standard delay caps may be used for delay detonation.

*d.* Acceptable results may be obtained by firing both rows simultaneously, if adequate means are sufficient time for delay firing are not available. However the resulting crater will not have the same depth and trapezoidal shape as described above.

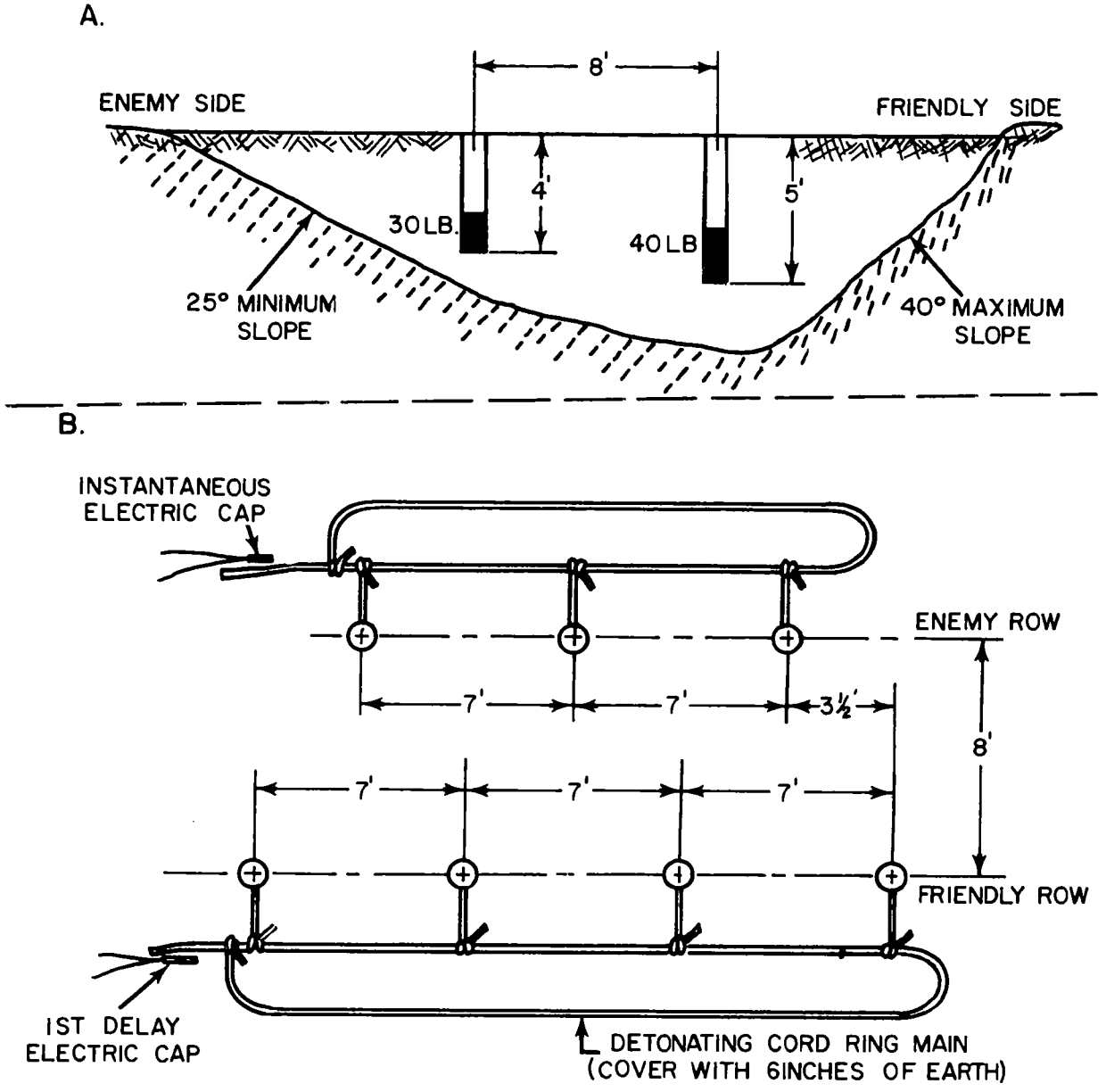



*Figure 3–18. Relieved face cratering.*

*e.* To prevent misfires from the shock and blast of the row of charges on the enemy side (detonated first), the detonating cord mains and branch lines of the row on the friendly side (detonated last) must be protected by a covering of about 6 inches of earth.

## 3–19. Angled Road Crater Method

This method is useful against tanks traveling in defiles or road cuts where they must approach the crater straightaway and is the most effective cratering method. The road crater is blasted using either the hasty or deliberate cratering methods described in paragraphs 3–16 and 3–17, except the boreholes are drilled across the roadway at about a 45° angle as shown in figure 3–19. Because of the angle at which tanks must attempt to cross an angled crater, they tend to slip sideways and ride off of their tracks.

## 3–20. Blasting Permafrost and Ice

*a. Blasting Permafrost.*

(1) *Number of boreholes and size of charge.* In permafrost, blasting requires about 1½ to

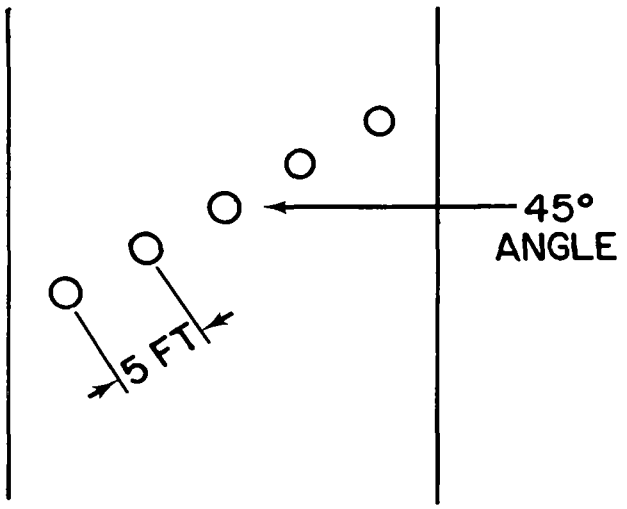



*Figure 3–19. Angled cratering method.*

2 times the number of boreholes and larger charges than those calculated by standard formulas for moderate climates. Frozen soil, when blasted, breaks into large clods 12 to 18 inches thick and 6 to 8 feet in diameter. As the charge has insufficient force to blow these clods clear of the hole, they fall back into it when the blast subsides. Testing to determine the number of boreholes needed should be made before extensive blasting is attempted. In some cases, permafrost may be as difficult to blast as solid rock.

(2) *Method of making boreholes.* Boreholes are made by three methods—use of standard drilling equipment, steam point drilling equipment, and shaped charges. Standard drill equipment has one serious defect—the air holes in the drill bits freeze and there is no known method of avoiding it. Steam point drilling is satisfactory in sand, silt or clay, but not in gravel. Charges must be placed immediately upon withdrawal of the steam point, otherwise the area around the hold thaws and plugs it. Shaped charges also are satisfactory for producing boreholes, especially for cratering. Table 3–5 shows the size of boreholes in permafrost and ice made by M3A1 and M2A4 shaped charges.

(3) *Explosives.* A low velocity explosive like ammonium nitrate, satisfactory for use in arctic temperatures, should be used, if available. The heaving quality of low velocity explosives will aid in clearing the hole of large boulders. If only high velocity explosives are available, charges should be tamped with water and permitted to freeze. Unless high velocity explosives are thoroughly tamped, they tend to blow out of the borehole.

*b. Blasting Ice.*

(1) *Access holes.* These are required for water supply and determining the thickness of ice for the computation of safe bearing pressures for aircraft and vehicles. As ice carries much winter traffic, its bearing capacity must be ascertained rapidly when forward movements are required. Small diameter access holes are made by shaped charges. On solid lake ice, the M2A4 penetrates 7 feet and the M3A1, 12 feet. These charges will penetrate farther but the penetration distances were tested only in ice approximately 12 feet thick. If the regular standoff is used, a large crater forms at the top, which makes considerable probing necessary to find the borehole. If a standoff of 42 inches or more is used with the M2A4 shaped charge, a clean hole without a top crater is formed. Holes made by the M2A4 average 3½ inches in diameter, while those made by the M3A1 average 6 inches.

(2) *Ice conditions.* In the late winter after the ice has aged, it grows weaker and changes color from blue to white. Although the structure of ice varies and its strength depends on age, air temperature, and conditions of the original formation, the same size and type of crater is formed regardless of the standoff distance. If the lake or river is not frozen to the bottom and there is a foot or more of water under the ice, the water will rise to within 6 inches of the top after the hole is blown, carrying shattered ice particles with it. This makes the hole easy to clean. If the lake is frozen to the bottom, the blown hole will fill with shattered ice and clearing will be extremely difficult. Under some conditions, shaped charges may penetrate to a depth much less than that indicated in table 3–5.

(3) *Surface charges.* Surface craters may be made with ammonium nitrate cratering charges or demolition blocks. For the best effects, the charges are placed on the surface of cleared ice and tamped on top with snow. The tendency of ice to shatter more readily than soil should be considered when charges are computed.

(4) *Underwater charges.*

(*a*) Charges are placed underwater by first making boreholes in the ice with shaped charges, and then placing the charge below the ice. An 80-pound charge of M3 demolition blocks under ice 4½ feet thick forms a crater 40 feet in diameter. This crater, however, is filled with floating ice particles, and at temperatures around 20° F. freezes over in 40 minutes.

(*b*) A vehicle obstacle may be cratered in ice by sinking boreholes 9 feet apart in staggered rows. Charges (tetrytol or plastic) are suspended about 2 feet below the bottom of the ice by means of cord with sticks bridging the tops of the holes. The size of the charge depends upon the thickness of the ice. An obstacle like this may retard or halt enemy vehicles for approximately 24 hours at temperatures around −24° F.

## 3–21. Cratering at Culverts

A charge detonated to destroy a culvert not more than 15 feet deep may, at the same time, produce an effective road crater. Explosive charges should be primed for simultaneous firing and thoroughly tamped with sandbags. Culverts with 5 feet or less of fill may be destroyed by explosive charges placed in the same manner as in hasty road cratering. Concentrated charges equal to 10 pounds per foot of depth are placed in boreholes at 5-foot intervals in the fill above and alongside the culvert.

## 3–22. Antitank Ditch Cratering

*a. Construction.* In open country, antitank ditches are constructed to strengthen prepared defensive positions. As they are costly in time and effort, much is gained if the excavation can be made by means of cratering charges. To be effective, an antitank ditch must be wide enough to stop an enemy tank. It may be improved by placing a log hurdle on the enemy side and the spoil on the friendly side. Ditches are improved by digging the face on the friendly side nearly vertical by means of handtools (para 3–15 *a*).

*b. Deliberate Cratering Method.* The deliberate cratering method outlined in paragraph 3–17 is adequate for the construction of heavy tank ditches in most types of soil.

*c. Hasty Cratering Method.* An antitank ditch may be constructed by placing 50 pounds of cratering explosive in 5-foot holes, and spacing the holes at 5-foot intervals (fig 3–16). The ditch crater will be approximately 8 feet deep and 25 feet wide.

## 3–23. Blasting of Ditches

In combat areas, ditches may be constructed to drain terrain flooded by the enemy or as initial excavations for the preparation of entrenchments. Rough open ditches 2½ to 12 feet deep and 4 to 40 feet wide may be blasted in most types of soils. A brief outline of the method is given below.

*a. Test Shots.* Before attempting the actual ditching, make test shots to determine the proper depth, spacing, and weight of charges needed to obtain the required results. Make beginning test shots with holes 2 feet deep and 18 inches apart and then increase the size of the charge and the depth as required. A rule of thumb for ditching is to use 1 pound of explosive per cubic yard of earth in average soil.

*b. Alinement and Grade.* Mark the ditch centerline by transit line or expedient means and drill holes along it. When a transit or hand level is used, the grade of the ditch may be accurately controlled by checking the hole depth every 5 to 10 holes and at each change in grade. In soft ground, the holes may be made with a sharp punch, a quicksand punch (fig 3–20) or an earth auger. Holes are loaded and tamped immediately to prevent cave-ins and insure that the charges are at proper depth. Ditches are sloped at a rate of 2 to 4 feet per 100 feet.

*c. Methods of Detonation.*

(1) *Propagation method.* By this method (fig 3–21) only one charge is primed—the charge placed in the hole at one end of the line of holes made to blast the ditch. The concussion from this charge sympathetically detonates the next charge and so on until all are detonated. Only 50–60 percent straight commercial dynamite should be used in this operation. The propagation method is effective, however, only in moist or wet soils and may be effectively used in swamps where the ground is covered by several inches of water. If more than one line of charges is required to obtain a wide ditch, the first charge of each line is primed. The primed hole is overcharged 1 or 2 pounds.

(2) *Electrical method.* Any high explosive may be used in ditching by the electrical firing method which is effective in all soils except sand, regardless of moisture content. Each charge is primed with an electric cap and the caps are connected in leapfrog series (para 2–6*b*). All charges are fired simultaneously.

(3) *Detonating cord method.* In this ditching method any high explosive may be used. It is effective in any type of soil, except sand, regardless of moisture content. Each charge is primed with detonating cord and connected to a detonating cord main or ring main line.

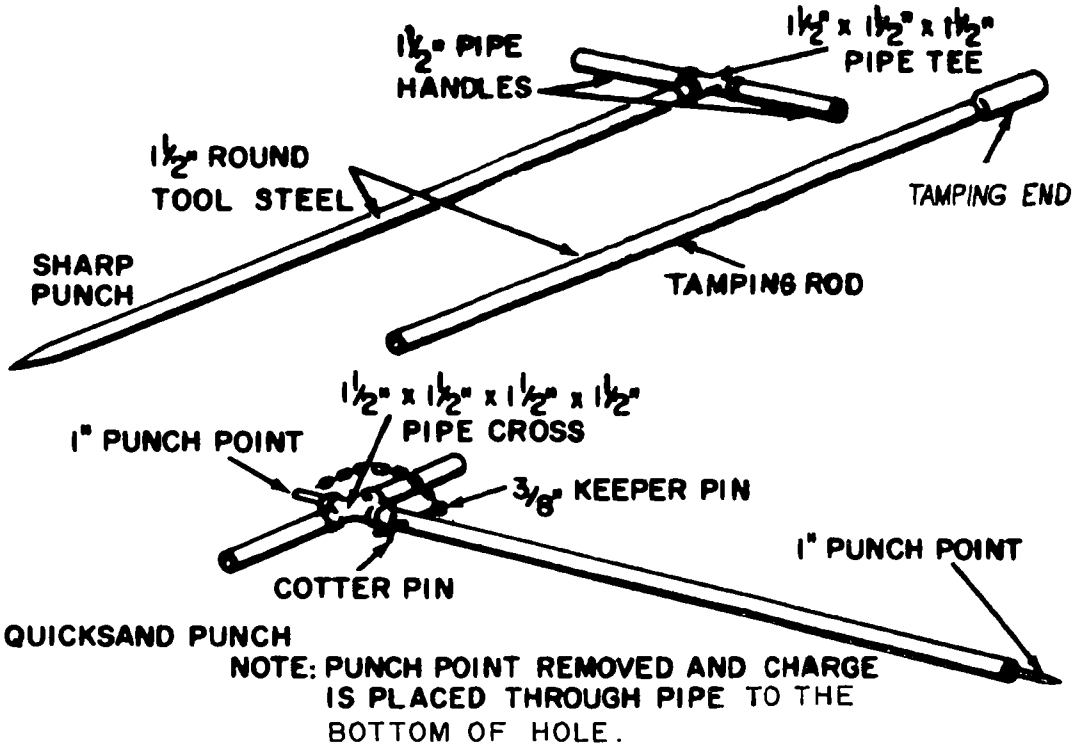



*Figure 3–20. Punches used to place charges at proper depths in soft ground.*

*d. Methods of Loading.*

(1) The method of loading for a deep, narrow ditch is illustrated in figure 3–22.

(2) The relief method of loading for shallow ditches is depicted in figure 3–23. Ditches 1 and 3 are blasted first to relieve ditch 2.

(3) Figure 3–24 shows the posthole method of loading for shallow ditches in mud.

(4) The cross section method of loading to clean and widen ditches is explained graphically in figure 3–25.

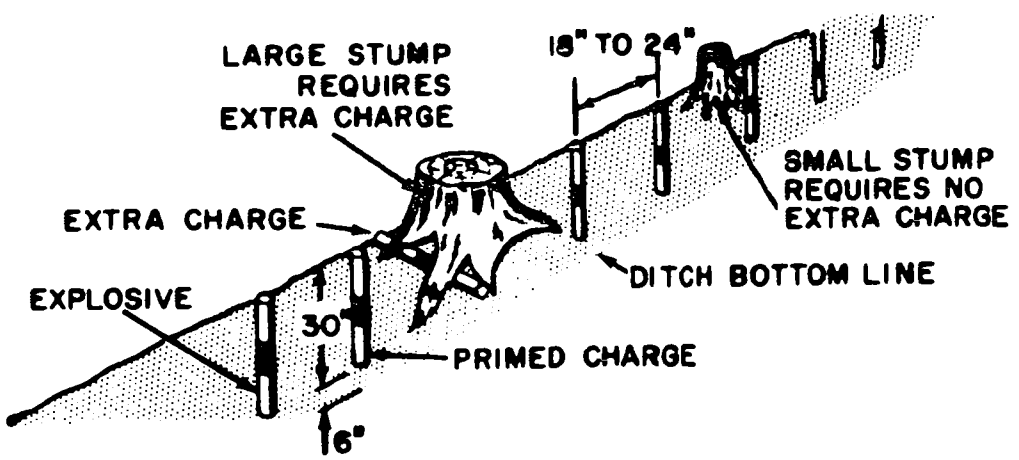



*Figure 3–21. Propagation method of detonation.*

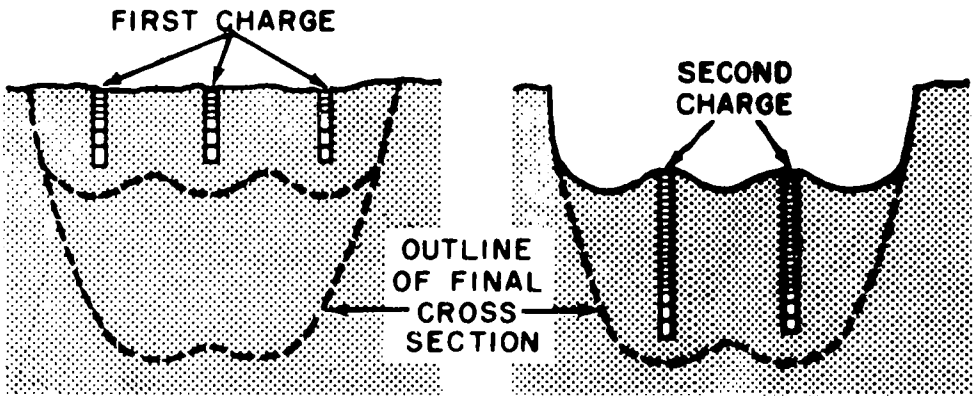



*Figure 3–22. Method of loading a deep narrow ditch.*

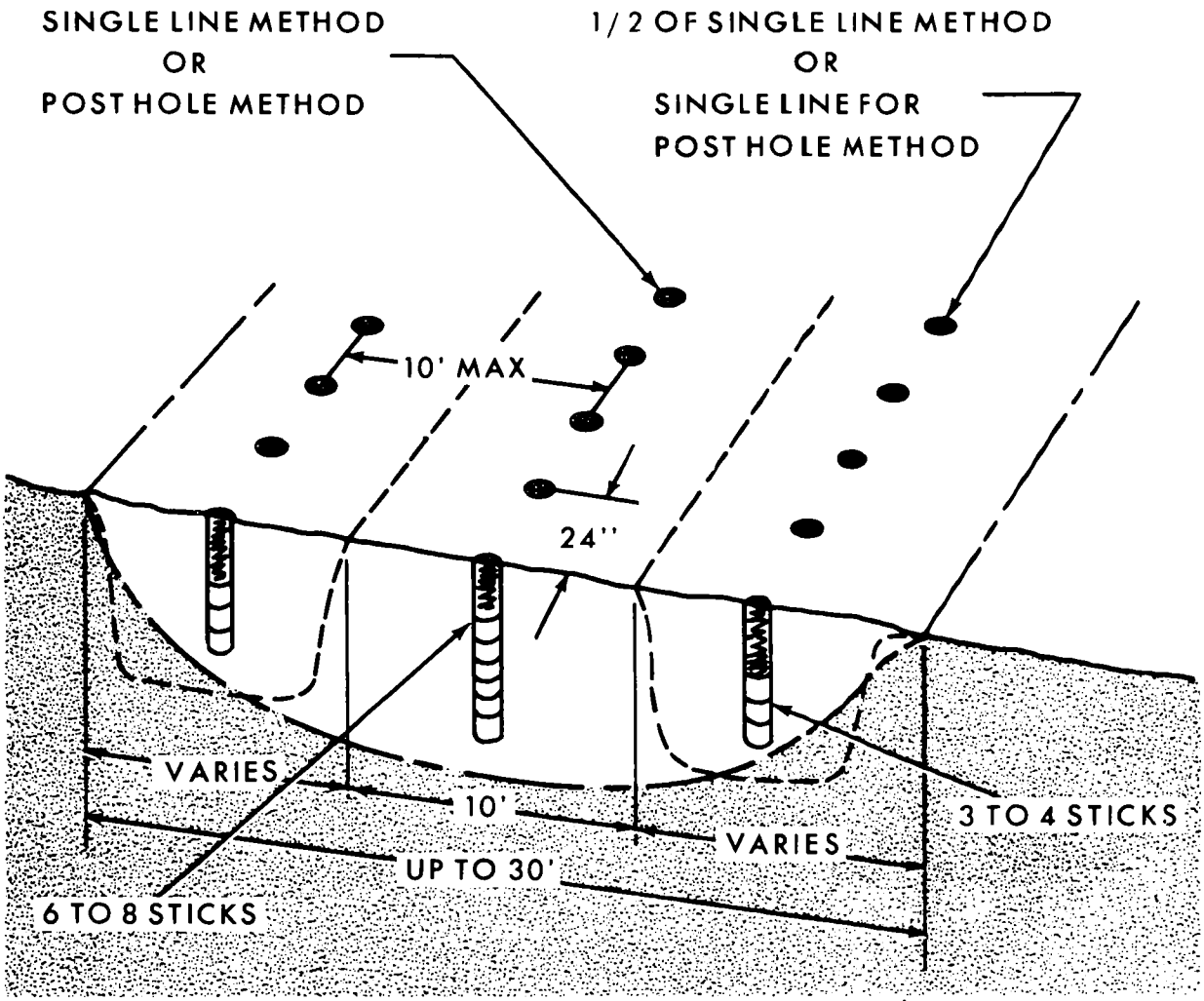



*Figure 3–23. Relief method of loading for shallow ditches.*

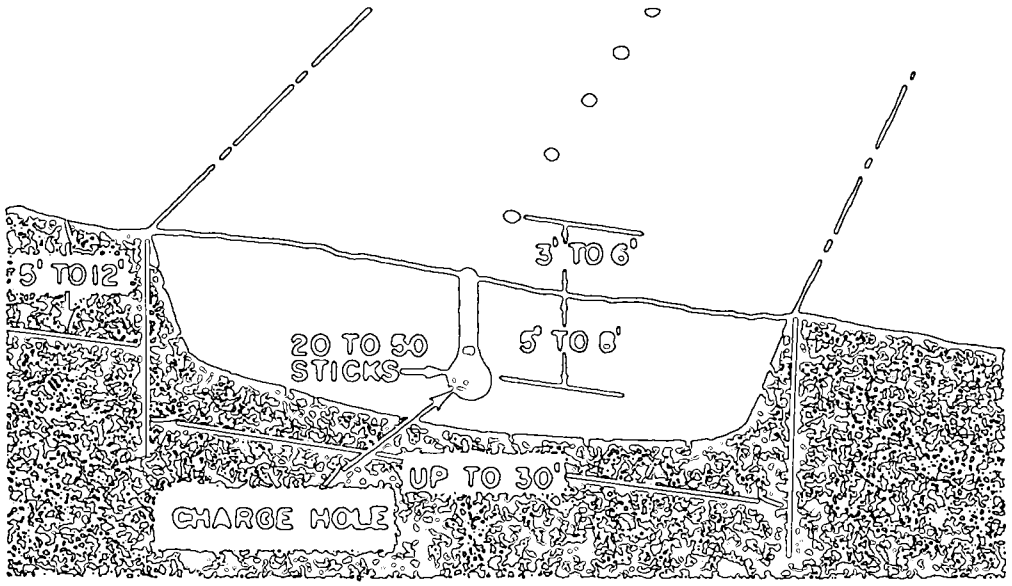



*Figure 3–24. Posthole method of loading for shallow ditches in mud.*

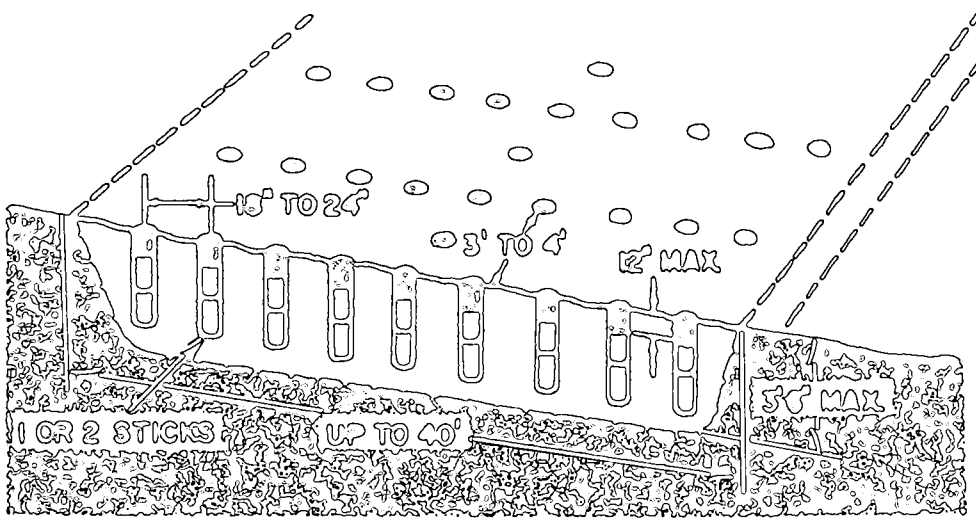



*Figure 3–25. Cross section method of loading to clean and widen ditches.*

## Section VII. LAND CLEARING CHARGES

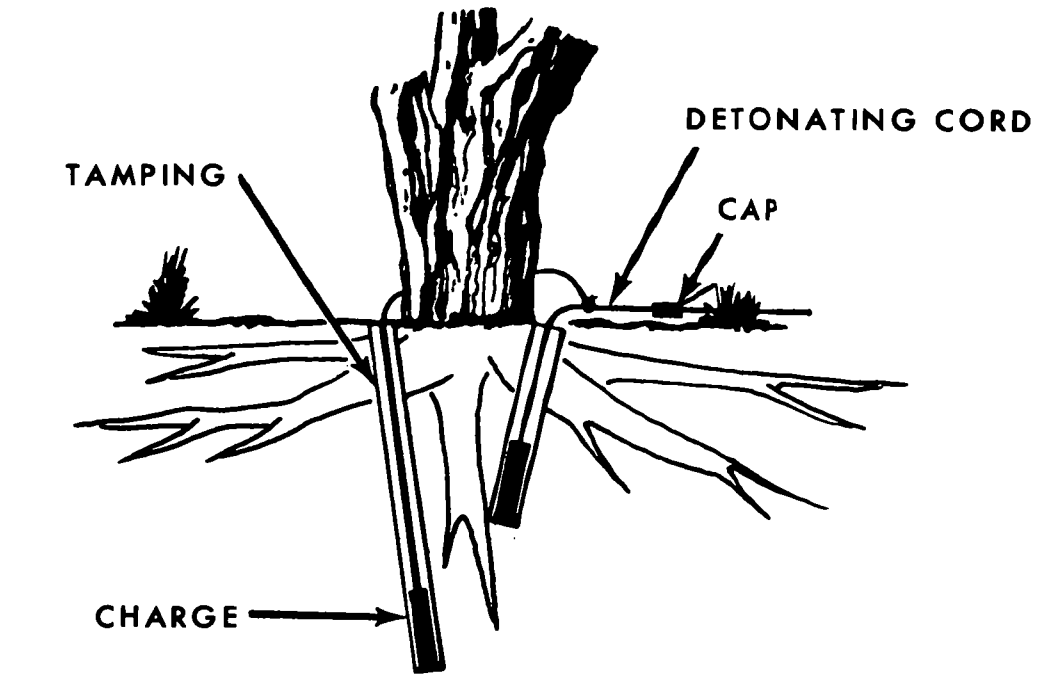
### 3–24. Introduction

In military operations, construction jobs occur in which explosives may be employed to advantage. Among these jobs are land clearing, which includes stump and boulder removal, and quarrying. The explosives commonly used are military and commercial dynamite and detonating cord. The quantity of explosive used is generally calculated by rule of thumb. Charges may be placed in boreholes in the ground under or at the side of the target, in the target itself, or on top of the target. All charges should be tamped or mudcapped, which is a form of light tamping.

### 3–25. Stump Removal

In certain military operations it may be necessary to remove stumps as well as trees. Stumps are of two general types, tap- and lateral-rooted (fig 3–26). Military dynamite is the explosive best suited for stump removal. A rule of thumb is to use 1 pound per foot of diameter for dead stumps and 2 pounds per foot for live stumps, and if both tree and stump are to be removed, to increase the amount of explosive by 50 percent. Measurements are taken at points 12 to 18 inches above the ground.

*a. Taproot Stumps.* For taproot stumps, one



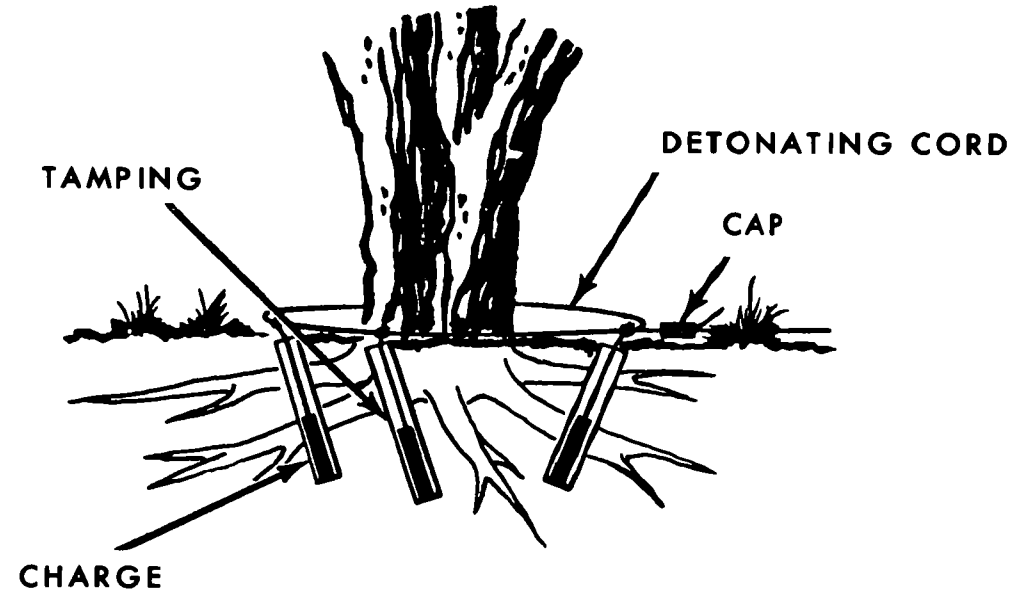




*Figure 3–26. Stump blasting charges.*

method is to bore a hole in the taproot below the level of the ground. The best method is to place charges on both sides of the taproot to obtain a shearing effect (fig 3–26). For best results, tamp the charges.

*b. Lateral-Root Stumps.* In blasting lateral root stumps, drill sloping holes as shown in figure 3–26. Place the charge as nearly as possible under the center of the stump and at a depth approximately equal to the radius of the stump base. If for some reason the root formation cannot be determined, assume that it is the lateral type and proceed accordingly.

## 3–26. Boulder Removal

In the building of roads and airfields or other

military construction, boulders can be removed by blasting. The most practical methods are snakeholing, mudcapping, and blockholing.

*a. Snakeholing Method.* By this method, a hole large enough to hold the charge is dug under the boulder. The explosive charge is packed under and against the boulder as shown in A, figure 3–27. For charge size, see table 3–6.

*b. Mudcapping Method.* For surface or slightly embedded boulders, the mudcapping method is very effective. The charge is placed on top or against the side of the boulder wherever a crack or seam exists that will aid in breakage, and covered with 10 to 12 inches of mud or clay (B, fig 3–27). For charge size see table 3–6.

*Table 3–6. Charge Size for Blasting Boulders.*

| Boulder diameter (ft) | Pounds of explosive required | | |
|---|---|---|---|
| | Blockholing | Snakeholing | Mudcapping |
| 3 | ¼ | ¾ | 2 |
| 4 | ⅜ | 2 | 3½ |
| 5 | ½ | 3 | 6 |

*c. Blockholing Method.* This method is very effective on boulders lying on the surface or slightly embedded in the earth. A hole is drilled on top of the boulder deep and wide enough to hold the amount of explosive indicated in table 3–6. The charge is then primed, put into the borehole, and stemmed (C, fig 3–27).

## 3–27. Springing Charges

*a. Definition and Method.* A springing charge is a comparatively small charge detonated in the bottom of a drilled borehole to form an enlarged chamber for placing a larger charge. At times two or more springing charges in succession may be needed to make the chamber large enough for the final charge. Under these conditions at least 2 hours should be allowed between firing and placing successive charges for the boreholes to cool unless the sprung holes are cooled with water or compressed air.

*b. Detonating Cord Wick.* This is several strands of detonating cord taped together and used to enlarge boreholes in soils. One strand generally widens the diameter of the hole about 1 inch.

(1) A hole is made by driving a steel rod approximately 2 inches in diameter into the ground to the depth required. According to the rule of thumb, a hole 10 inches in diameter requires 10 strands of detonating cord. These must extend the full length of the hole and be taped or tied together into a "wick" to give optimum results. The wick may be placed into the hole by an inserting rod or some field expedient. Firing may be done electrically or nonelectrically. An unlimited number of wicks may be fired at one time by connecting them by a detonating cord ring main or line main.

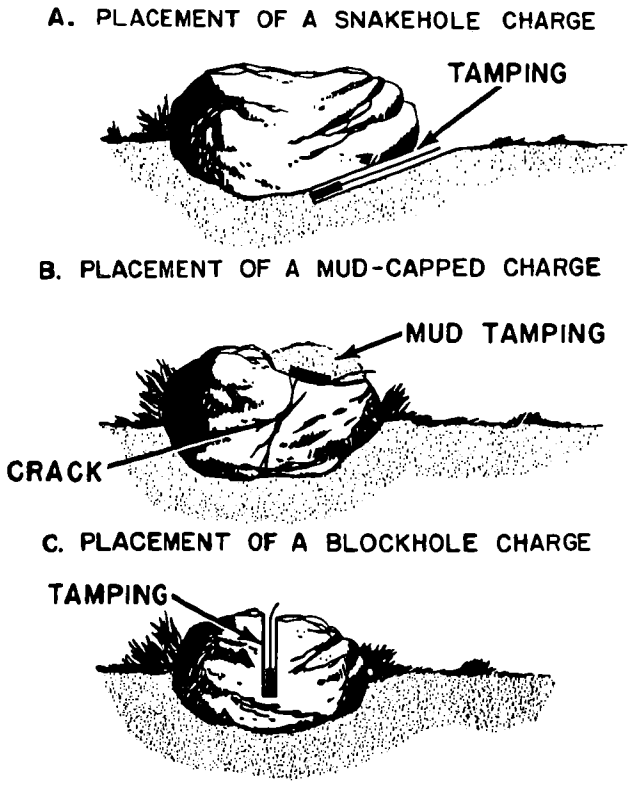



*Figure 3–27. Boulder blasting charges.*

(2) The best results from the use of the detonating cord wick are obtained in hard soil. If successive charges are placed in the holes, excess gases must be blown out and the hole inspected for excessive heat.

## 3–28. Quarrying

Quarrying is the extraction of rock in the natural state. Military quarries, generally of the open face type, are developed by the single or multiple bench method. See TM 5–332 for detailed information.

# CHAPTER 4

# DEMOLITION PROJECTS

## Section I. DEMOLITION PLAN

### 4–1. Scope

Thus far, this manual has been concerned with methods and techniques in the selection, calculation, priming, placement, and firing of explosives on such materials as steel, concrete, wood, and stone, and in earth. This chapter deals with the problems of applying these techniques to the conduct of demolition projects.

### 4–2. Demolition Obstacles

Although demolitions may be employed in a wide range of demolition projects, such as quarrying, land clearing, ambushes, and so on, probably the most important military use of demolitions is that of creating demolition obstacles. Demolition obstacles are used in conjunction with many other types of obstacles including mines, to create barriers to control the movement of an opposing force. Demolitions are also used in denial operations to create obstacles and to destroy facilities or material.

### 4–3. Barriers and Denial Operations

The employment of extensive barriers and execution of denial operations are normally directed by division or higher commanders. They are based upon careful planning and closely coordinated with all tactical plans. Engineer units are responsible for furnishing technical advice and supervision, siting and constructing specific obstacles or barriers, estimating the requirements for obstacle materials, and recommending the allocation of engineer resources. Because the use of demolitions requires special skills and equipment, the construction of demolition obstacles is normally assigned to engineer units. For further information see FM 31–10.

### 4–4. Demolition Planning

The execution of a demolition project must be based upon careful planning and reconnaissance (para 4–5). Factors that determine the selection and extent of demolition projects are as follows:

*a.* The mission of the command.

*b.* Limitations and instructions of higher authority.

*c.* The current tactical and strategical situation and future plans that indicate the length of time the enemy must be delayed, the time available for demolition, and the entent of denial to be accomplished.

*d.* Enemy capabilities and limitations and the effect of the denial upon him strategically and tactically.

*e.* The likelihood that friendly forces may reoccupy the area and be required to neutralize the obstacle.

*f.* The results to be obtained by the expenditure of labor and materials compared to the results that may be obtained elsewhere with the same amount of effort.

*g.* The time, materials, labor, and equipment available.

*h.* The effect upon the local population.

*i.* The target protection required.

### 4–5. Demolition Reconnaissance

*a. Demolition Reconnaissance Report.* Thorough reconnaissance is necessary before a plan may be made to demolish a target, as reconnaissance provides information in all areas related to the project. DA Form 2203–R (Demolition Reconnaissance Report) (fig 4–1), together with appropriate sketches, is used to record and report the reconnaissance of a military demolition project. This report is used to provide information for the preparation of a nonnuclear demolition target folder (para 4–7) when time and conditions permit; it may also be used in lieu of the target folder when one is not avail-

able. The information provided by the form and listed in *b* below, is intended primarily for bridge and road demolitions, but is also applicable to the demolition of almost any other object. In certain instances the report may require a security classification. DA Form 2203–R will be locally reproduced on 8- by 10½-inch paper (image size 7″ x 9⅙″).

*b. Information Required.* The Demolition Reconnaissance Report should contain the following information:

(1) Situation map sketch showing the relative position of the objects to be demolished, the surrounding terrain features, and the coordinates of the objects keyed to existing maps.

(2) List of all unusual features of the site, giving location on situation map sketch (1) above.

(3) Plan and side view sketch of the demolition object showing overall dimensions, lines of cut and demolition chambers. If, for example, a bridge is to be destroyed, a sketch showing the overall dimensions of critical members is necessary.

(4) Plans and cross section sketches, showing details of chambers, lines of cut and location of charges, with relatively accurate dimensions of each member to be cut, giving quantities of explosives, and method of ignition.

(5) Sketch showing firing circuits and firing point.

(6) A bill of explosives, showing the quantity and types required.

(7) List of all equipment, including transportation, required for the demolition.

(8) Estimate of time and labor required for preparing the demolitions and placing the charges.

(9) Estimate of time and labor required for arming the charges and firing the demolition (see para 4–6*e*).

(10) Estimate of time, labor, and equipment required to bypass the obstacle, specify location and method. Include supplementary obstacles, such as mining, required.

## 4–6. Demolition Orders (Stanag 2017, Edition 2)

*a. Purpose.* Three commanders are usually involved in the execution of a demolition project. These are the tactical or authorized commanders with overall responsibility and authority to order the firing of the demolition, the commander of the demolition guard, and the commander of the demolition firing party. To assist these commanders in the execution of their responsibilities, two demolition orders are used. These orders are shown in figure 4–2 (Orders to the Demolition Guard Commander) and in figure 4–3 (Orders to the Demolition Firing Party Commander) (DA Form 2050–R). These orders and the procedures that follow are in accordance with the Standardization Agreement (STANAG) 2017, Edition 2 dated 5 October 1964, and must be followed by U.S. Army units.

*b. Procedures.* Each authorized commander referred to in *a* above, will:

(1) Establish the requirement and assign the responsibility for a demolition guard and a demolition firing party.

(2) Establish a clear cut channel whereby the order to fire the demolition is transmitted from himself to the commander of the demolition guard and thereby to the commander of the demolition firing party. In the event that no demolition guard is required this channel must be established between the authorized commander and the commander of the demolition firing party.

(3) Insure that this channel is known and understood by all concerned, and that positive and secure means of transmitting the order to fire are established.

(4) Specify the conditions for executing the demolition as contained in part V of DA Form 2050–R (Orders to the Demolition Firing Party Commander), and complete part IV of the "Orders to the Demolition Guard Commander."

*c. Orders to the Demolition Guard Commander.* The authorized commander completes and signs this format. The order is written in seven parts, each of which is self-explanatory.

*d. Orders to the Demolition Firing Party Commander.* In addition to those items listed in *b* above, the authorized commander designates the unit or individual responsible for the preparation of these orders. DA Form 2050–R will be used for this purpose. DA Form 2050–R will be locally reproduced on 8- by 10½-inch paper (image size, 7″ x 9⅘″). This unit or individual will complete and sign parts I through III and pass the order to the commander of the demolition firing party. Part IV will be completed upon detonation of the demolition (fig 4–3).

DEMOLITION RECONNAISSANCE REPORT
(FM 5-25)

SECTION I - GENERAL

| 1. FILE No. | 2. DML RECON RPT No. | 3. DATE | 4. TIME |
|---|---|---|---|
| | | | |

| | NAME | GRADE | ORGANIZATION |
|---|---|---|---|
| 5. RECON ORDERED BY | | | |
| 6. PARTY LEADER | | | |

| 7. MAP NAME | SCALE | SHEET # | SERIES # |
|---|---|---|---|
| | | | |

| 8. TARGET AND LOCATION | 9. TIME OBSERVED | 10. COORDINATES |
|---|---|---|
| | | |

11. GENERAL DESCRIPTION (attach sketches)

12. NATURE OF PROPOSED DEMOLITION (attach sketches)

13. UNUSUAL FEATURES OF SITE

SECTION II - ESTIMATES*

| 14. EXPLOSIVES REQUIRED | | c. Caps | d. Detonating Cord | f. Fuse Lighters |
|---|---|---|---|---|
| a. Types | b. Quantity | Electric | | |
| | | Nonelectric | e. Time Fuse | g. Firing Wire |

15. EQUIPMENT AND TRANSPORT REQUIRED

| 16. PERSONNEL AND TIME REQUIRED FOR: | NCO's | Men | Time |
|---|---|---|---|
| a. PREPARING AND PLACING THE CHARGES | | | |
| b. ARMING AND FIRING THE DEMOLITION | | | |

17. TIME, LABOR AND EQUIPMENT REQUIRED FOR BYPASS; SPECIFY LOCATION AND METHOD

* Determine availability of Items 14, 15 and 16 before reconnaissance.

DA FORM 2203-R, 1 Aug 70 Edition of 1 Mar 67 is obsolete.

(Paper size, 8" x 10½"; image size, 7" x 9-1/6")

*Figure 4-1. Demolition Reconnaissance Report, DA Form 2203-R.*

Serial No._____ Security Classification_____

ORDERS TO THE DEMOLITION GUARD COMMANDER

Notes: 1. This format will be completed and signed before it is handled to the Commander of the Demolition Guard.

2. In completing the format, all spaces must either be filled in or lined out.

3. The officer empowered to order the firing of the demolition is referred to throughout as the "Authorized Commander."

From_____ To_____

PART I - PRELIMINARY INSTRUCTIONS

1. a. Description of target_____

b. Location:

Map Name and Scale_____Sheet No._____

Grid Reference_____

c. Codeword or codesign (if any) of demolition target_____

2. The Authorized Commander is_____
(give appointment only). If this officer should delegate his authority, you will be notified by one of the methods shown in paragraph 4, below.

3. The DEMOLITION FIRING PARTY has been/will be provided by_____
_____

4. All messages, including any codewords or codesigns (if any) used in these orders, will be passed to you by:

a. Normal command wireless net, or

b. Special liaison officer with communications direct to the Authorized Commander, or

c. Telephone by the Authorized Commander, or

d. The Authorized Commander personally, or

e. _____
(Delete those NOT applicable)

Note: All orders sent by message will be prefixed by the codeword or codesign (if any) at paragraph 1.c., and all such messages must be acknowledged.

SECURITY CLASSIFICATION

*Figure 4-2. Orders to the demolition guard commander.*

SECURITY CLASSIFICATION

PART II - CHANGING STATES OF READINESS

5. The demolition will be prepared initially to the State of Readiness: _____, by _____hours on _____(date).

6. On arrival at the demolition site, you will ascertain from the Commander of the Demolition Firing Party the estimated time required to change from State "1" (SAFE) to State "2" (ARMED). You will ensure that this information is passed to the Authorized Commander and is acknowledged.

7. Changes in the State of Readiness from State "1" (SAFE) to State "2" (ARMED) or from State "2" to State "1" will be made only when so ordered by the Authorized Commander. However, the demolition may be ARMED in order to accomplish emergency firing when you are authorized to fire it on your own initiative.

8. A record of the changes in the State of Readiness will be entered by you in the table below, and on the firing orders in the possession of the Commander of the Demolition Firing Party.

| State of Readiness ordered: "1" (SAFE) or "2" (ARMED) | Time & Date change to be completed | Authority | Time & Date of receipt of order |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

Note: If the order is transmitted by an officer in person, his signature and designation will be obtained in the column headed "Authority."

9. You will report completion of all changes in the State of Readiness to the Authorized Commander by the quickest means.

PART III - ORDERS FOR FIRING THE DEMOLITION

10. The order for firing the demolition will be passed to you by the Authorized Commander.

11. On receipt of this order you will immediately pass it to the Commander of the Demolition Firing Party on his demolition orders form (DA Form 2050-R, Orders to the Commander, Demolition Firing Party).

12. After the demolition has been fired you will report the results immediately to the Authorized Commander.

13. In the event of a misfire or only partially successful demolition you will give the firing party protection until such time as it has completed the demolition and report again after it has been completed.

SECURITY CLASSIFICATION

*Figure 4-2*—Continued.

SECURITY CLASSIFICATION

PART IV - EMERGENCY FIRING ORDERS

Notes: 1. One sub-paragraph of paragraph 14 must be deleted.

2. The order given herein can only be altered by the issue of a new form, or, in emergency, by the appropriate order (or codeword, if used) in Part V.

14. a. You will order the firing of the demolition only upon the order of the Authorized Commander.

OR

b. If the enemy is in the act of capturing the target, and/or munition, you will order the firing of the demolition on your own initiative.

PART V - CODEWORDS (IF USED)

| | Action to be taken | Codeword |
|---|---|---|
| a. | Change State of Readiness from "1" to "2". (See paragraph 7) | |
| b. | Change State of Readiness from "2" to "1". (See paragraph 7) | |
| c. | Fire the demolition. (See paragraph 10) | |
| d. | Paragraph 14.a. is now cancelled. You are now authorized to fire the demolition, if the enemy is in the act of capturing it. | |
| e. | Paragraph 14.b. is now cancelled. You will order the firing of the demolition only upon the order of the Authorized Commander. | |
| f. | Special authentication instructions, if any. | |

PART VI

Signature of officer issuing these orders_____

Name (printed in capital letters)_____

Rank_____Appointment_____

Time of issue_____hours,_____(date).

SECURITY CLASSIFICATION

*Figure 4-2*—Continued.

SECURITY CLASSIFICATION

PART VII - DUTIES OF THE COMMANDER OF THE DEMOLITION GUARD

15. You are responsible for --

a. Command of the demolition guard and the demolition firing party.

b. The safety of the demolition from enemy attack, capture, or sabotage.

c. Control of traffic and refugees.

d. Giving the orders to the demolition firing party in writing to change the state of readiness.

e. Giving the order to the demolition firing party in writing to fire the demolition.

f. After the demolition, reporting on its effectiveness to the Authorized Commander.

g. Keeping the Authorized Commander informed of the operational situation at the demolition site.

16. You will acquaint yourself with the orders issued to the Commander of the Demolition Firing Party and with the instructions given by him.

17. The Demolition Guard will be so disposed as to ensure at all times complete all-round protection of the demolition against all types of attack or threat.

18. The Commander of the Demolition Firing Party is in technical control of the demolition. You will agree with him on the site of your Headquarters and of the firing point. These should be together whenever practicable. When siting them you must give weight to the technical requirements of being able to view the demolition and have good access to it from the firing point.

19. You will nominate your deputy forthwith and compile a seniority roster. You will ensure that each man knows his place in the roster, understands his duties and knows where to find this form if you become a casualty or are unavoidably absent. The seniority roster must be made known to the Commander of the Demolition Firing Party.

20. Once the State of Readiness "2" (ARMED) has been ordered, either you or your deputy must always be at your Headquarters so that orders can be passed on immediately to the Commander of the Demolition Firing Party.

SECURITY CLASSIFICATION

*Figure 4-2*—Continued.

SECURITY CLASSIFICATION

| ORDERS TO THE COMMANDER, DEMOLITION FIRING PARTY | SERIAL NUMBER |
|---|---|

NOTE: Parts I, II and III will be completed and signed before this form is handed to the commander of the Demolition Firing Party. Paragraphs 4 and 5 can only be altered by the authority issuing these orders. In such cases a new form will be issued and the old one destroyed.

| FROM: | TO: |
|---|---|

PART I - ORDERS FOR PREPARING AND CHARGING THE DEMOLITION TARGET

1a. DESCRIPTION

| b. LOCATION | | | c. CODE WORD OF DEMOLITION TARGET (If any) |
|---|---|---|---|
| MAP NAME AND SCALE | SHEET NO. | GRID REFERENCE | |
| | | | |

d. ATTACHED PHOTOGRAPHS AND SPECIAL TECHNICAL INSTRUCTIONS

2. THE DEMOLITION GUARD IS BEING PROVIDED BY (Unit)

3. YOU WILL PREPARE AND CHARGE THE DEMOLITION TARGET TO THE STATE OF READINESS _____ BY _____ HOURS ON (Date)_____
ANY CHANGES MAY ONLY BE MADE ON THE ORDER OF THE ISSUING AUTHORITY, OR BY THE OFFICER DESIGNATED IN PARAGRAPH 4d AND WILL BE RECORDED BELOW.

| STATE OF READINESS ORDERED "1(SAFE)" or "2(ARMED)" | TIME AND DATE CHANGE TO BE COMPLETED | AUTHORITY | TIME AND DATE OF RECEIPT OF ORDER |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

NOTE: All orders received by message will be verified by the code word at Paragraph 1c. If the order is transmitted by an officer in person, his signature and designation will be obtained in the Column headed "Authority".

PART II - ORDERS FOR FIRING

NOTE: The officer issuing these orders will strike out the subparagraphs of Paragraphs 4 and 5 which are not applicable. When there is a demolition guard, Paragraph 4 will always be used and Paragraph 5 will always be struck out.

4a. YOU WILL FIRE THE DEMOLITION AS SOON AS YOU HAVE PREPARED IT.
b. YOU WILL FIRE THE DEMOLITION AT _____ HOURS ON (Date)_____.
c. YOU WILL FIRE THE DEMOLITION ON RECEIPT OF THE CODE WORD _____.
d. YOU WILL FIRE THE DEMOLITION WHEN THE OFFICER WHOSE DESIGNATION IS _____ HAS SIGNED PARAGRAPH 8 BELOW.

EMERGENCY FIRING ORDERS (ONLY applicable when there is NO demolition guard)

5a. YOU WILL NOT FIRE THE DEMOLITION IN ANY CIRCUMSTANCES EXCEPT AS ORDERED IN PARAGRAPH 4 ABOVE.
b. YOU WILL FIRE THE DEMOLITION ON YOUR OWN INITIATIVE IF THE ENEMY IS IN THE ACT OF CAPTURING IT.

DA FORM 2050-R, 1 NOV 57 SECURITY CLASSIFICATION

*Figure 4-8. Orders to the demolition firing party commander.*

SECURITY CLASSIFICATION

PART III - ORDERS FOR REPORTING

6. AFTER FIRING THE DEMOLITION YOU WILL IMMEDIATELY REPORT RESULTS TO THE OFFICER WHO ORDERED YOU TO FIRE. IN THE EVENT OF A PARTIAL FAILURE YOU WILL WARN HIM, AND IMMEDIATELY CARRY OUT THE WORK NECESSARY TO COMPLETE THE DEMOLITION

7. FINALLY, YOU WILL IMMEDIATELY REPORT THE RESULTS TO YOUR UNIT COMMANDING OFFICER (See Paragraph 13.)

| SIGNATURE OF OFFICER ISSUING THESE ORDERS | NAME (In capitals)<br>DESIGNATION | TIME OF ISSUE | DATE OF ISSUE |
|---|---|---|---|
| | | | |

PART IV - ORDER TO FIRE

8. BEING EMPOWERED TO DO SO, I ORDER YOU TO FIRE NOW THE DEMOLITION DESCRIBED IN PARAGRAPH 1.

| SIGNATURE | NAME (In capitals)<br>DESIGNATION | TIME | DATE |
|---|---|---|---|
| | | | |

PART V - GENERAL INSTRUCTIONS (Read These Instructions Carefully)

9. YOU ARE IN TECHNICAL CHARGE OF THE PREPARATION, CHARGING AND FIRING OF THE DEMOLITION TARGET DESCRIBED. YOU WILL NOMINATE YOUR DEPUTY FORTHWITH AND COMPILE A SENIORITY ROSTER OF YOUR PARTY. YOU WILL INSURE THAT EACH MAN KNOWS HIS PLACE IN THE ROSTER, UNDERSTANDS THESE INSTRUCTIONS, AND KNOWS WHERE TO FIND THIS FORM IF YOU ARE HIT OR UNAVOIDABLY ABSENT. YOU WILL CONSULT WITH THE COMMANDER OF THE DEMOLITION GUARD ON THE SITING OF THE FIRING POINT.

10. YOU MUST UNDERSTAND THAT THE COMMANDER OF THE DEMOLITION GUARD (where there is one) IS RESPONSIBLE FOR:
   a. OPERATIONAL COMMAND OF ALL THE TROOPS AT THE DEMOLITION SITE. (You are therefore under his command.)
   b. PREVENTING THE CAPTURE OF THE DEMOLITION SITE, OR INTERFERENCE BY THE ENEMY WITH DEMOLITION PREPARATIONS.
   c. CONTROLLING ALL TRAFFIC AND REFUGEES.
   d GIVING YOU THE ORDER TO CHANGE THE STATE OF READINESS FROM "1(SAFE)" TO "2(ARMED)" OR BACK TO "1(SAFE)" AGAIN. YOU WILL INFORM HIM OF THE TIME REQUIRED FOR SUCH A CHANGE.
   e. PASSING TO YOU THE ACTUAL ORDER TO FIRE.

11. WHEN THERE IS NO DEMOLITION GUARD AND YOU ARE INSTRUCTED IN PARAGRAPH 4 TO ACCEPT THE ORDER TO FIRE FROM SOME PARTICULAR OFFICER, IT IS IMPORTANT THAT YOU ARE ABLE TO IDENTIFY HIM.

12. IF YOU GET ORDERS TO FIRE, OTHER THAN THOSE LAID DOWN IN PARAGRAPH 4, YOU SHOULD REFER THEM TO THE DEMOLITION GUARD COMMANDER OR, IF THERE IS NO DEMOLITION GUARD COMMANDER, TO YOUR IMMEDIATE SUPERIOR. IF YOU CANNOT DO THIS, YOU WILL ONLY DEPART FROM YOUR WRITTEN INSTRUCTIONS WHEN YOU ARE SATISFIED AS TO THE IDENTITY AND OVERRIDING AUTHORITY OF WHOEVER GIVES YOU THESE NEW ORDERS, AND YOU WILL GET HIS SIGNATURE IN PARAGRAPH 8 WHENEVER POSSIBLE.

13. THE REPORT TO YOUR UNIT COMMANDING OFFICER, AS CALLED FOR IN PARAGRAPH 7, SHOULD CONTAIN THE FOLLOWING INFORMATION (where applicable):
   a. IDENTIFICATION REFERENCE OF DEMOLITION.
   b. MAP REFERENCE.
   c. TIME AND DATE WHEN DEMOLITION WAS FIRED.
   d. EXTENT OF DAMAGE ACCOMPLISHED, INCLUDING:
      ESTIMATED WIDTH OF GAP)
      NUMBER OF SPANS DOWN ) IN CASE OF A BRIDGE
      SIZE AND LOCATION OF CRATERS IN A LOAD OR RUNWAY.
      MINES LAID.
   e. SKETCH SHOWING EFFECT OF DEMOLITION.

SECURITY CLASSIFICATION

*Figure 4-3*—**Continued.**

*e. Definitions.* The states of readiness (safe and armed) referred to in part I of the Order to the Demolition Firing Party Commander and in part II of the Order to the Demolition Guard Commander, are described as follows:

(1) *"1 (Safe)."* The explosive charges are prepared and securely fixed to the target and are safe against premature firing. All firing circuits and accessories have been checked, are in proper operating condition, and are ready to be attached to charges. If detonating cord is used it may be attached to demolition charges; however, detonators will not be attached to detonating cord ring mains or main lines until the state of readiness is changed to "armed."

(2) *"2 (Armed)."* The demolition is ready for immediate firing. The risk of premature detonation is accepted.

*f. Disposition of Orders.* After the demolition has been fired, one copy of the orders will be retained by the headquarters of the issuing authority and one by the commander of the demolition firing party.

## 4–7. Nonnuclear Demolition Target Folder

*a. Purpose.* The nonnuclear demolition target folder is prepared to provide all the information needed to destroy a target. It is prepared for all nonnuclear demolitions targets planned in barrier and denial operations (see FM 31–10). Whenever time and conditions permit, the target folder will be prepared in the format of the nonnuclear demolition target folder described below and illustrated in figure 4–4. The folder and procedures that follow are in accordance with the STANAG 2123, dated 12 July 1968.

*b. Contents.* The nonnuclear demolition target folder consists of four parts.

(1) Location of targets.
(2) Supply of explosives and equipment.
(3) Orders for preparing and firing.
(4) Demolition report.

The parts are to be in the order indicated above and in the pattern illustrated in figure 4–4. If additional information is considered necessary, it is to be inserted in the appropriate place in the folder. When there is insufficient space to enter the information, additional pages may be inserted. In such cases, the words, for example, "see page 4a" are inserted at the appropriate place and the additional page is inserted immediately following the notation.

*c. Format.* The nonnuclear demolition target folder is intended to be used in the field by the commander of the demolition firing party and must have a strong, durable cover and be bound so that pages with maps, stores lists, report forms, etc., can be easily removed. It is to be prepared in a pocket size, about 6- by 8¼-inches.

*d. Language.*

(1) Situations could arise where the unit responsible for implementing a demolition is of a different nationality from the unit preparing the folder. It is therefore essential to produce the nonnuclear demolition target folder in a multilingual form.

(2) The nonnuclear demolition target folder is to be prepared in the following languages:

(*a*) Language(s) of units concerned.
(*b*) Language of the host nation.
(*c*) One of the two official NATO languages (English or French).

(3) All subject matter in the folder is to be completed in all languages agreed for the folder. Notes on maps, plans, sketches, etc., are to be in one language only, with a translation at the bottom of the page of relevant items in the other languages.

*e. Special Instructions.* The following instructions apply to the format shown in figure 4–4.

(1) *List of Explosives and Stores Required (Part (2c) of the Folder).* The list given in the format (fig 4–4) is not intended to be exhaustive. It does indicate, however, a logical order of recording the various items. The list is to include only those items required for a particular target.

(2) *Special Technical Instructions (Part (3a) of the Folder).* In the case of a major task, the size, composition and mission of the various parties employed on preparations are to be noted in paragraph 5, Organization of Work.

(3) *Mines (Part (3e) of the Folder).* This part concerns only nuisance mines, if applicable, or protective mines laid to protect the target and does not mean barrier minefields. Barrier minefields are referred to in paragraph 7b of Part (3a) of the folder.

(4) *Demolition Report (Part (4) of the Folder).* Paragraphs *a* and *b* are filled in when the folder is prepared. This sheet can be detached for use as a demolition report form upon completion of the demolition. Squared paper is provided at the back for making a sketch.

| Security Classification (after completion) Classement de Sécurité (une fois remple) | |
|---|---|

NON-NUCLEAR
DEMOLITION TARGET FOLDER

CARNET DE DISPOSITIF DE DESTRUCTION PREPARE
NON NUCLEAIRE

| TARGET No. | DISPOSITIF No. | |
|---|---|---|
| | | |

| | CLASS | CATEGORIE | |
|---|---|---|---|
| * | 1. PRELIMINARY | 1. PRELIMINAIRE | |
| * | 2. RESERVED | 2. DEMANOEUVRE (1)<br>RESERVE (1) | |

ATTENTION

DO NOT ALLOW TO FALL INTO ENEMY HANDS

NE PAS LAISSER TOMBER AUX MAINS DE L'ENEMI

NOTE
* Strike out items not applicable/
Rayer la mention inutile.
(1) Delete the term not used/
Barrer la mention non utilisée.

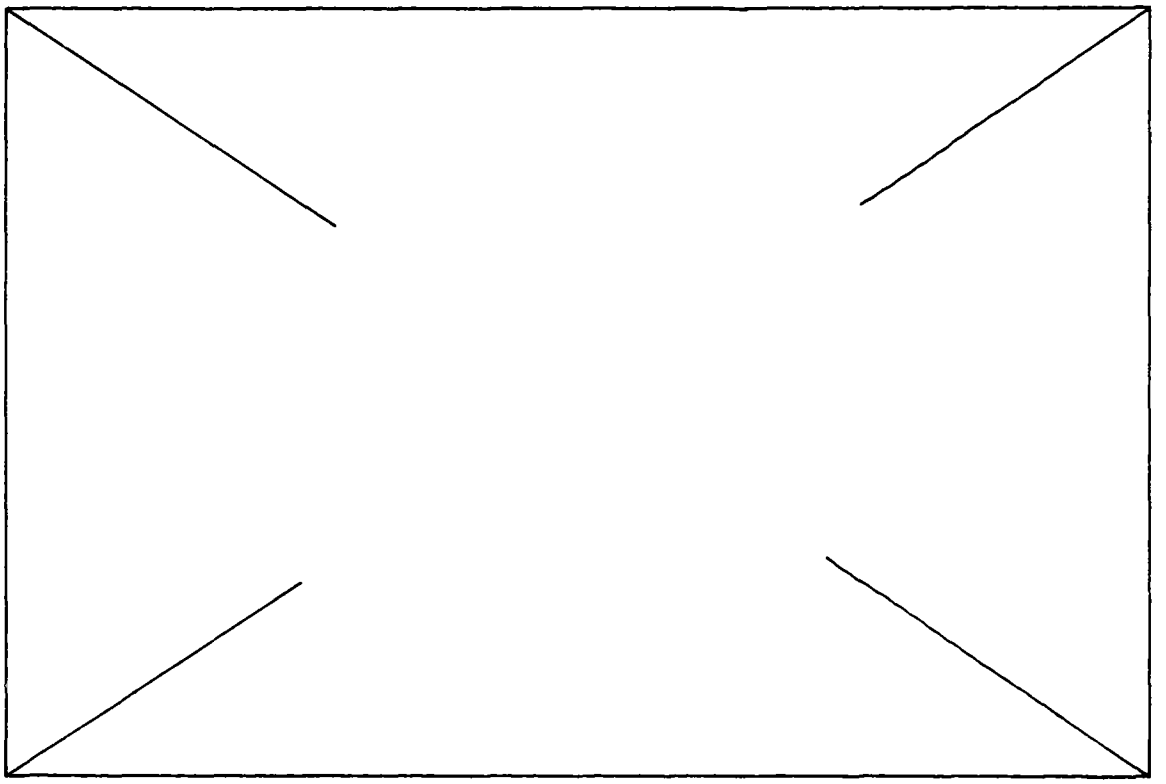
| COPY No. | EXEMPLAIRE No. | |
|---|---|---|
| | | |

FRONT COVER
Security Classification

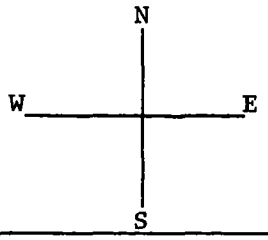
*Figure 4-4. Nonnuclear demolition target folder.*

(Security Classification)

(1) PHOTOGRAPH OF TARGET | PHOTOGRAPHIE DE L'OUVRAGE | _____



| DESCRIPTION | DESCRIPTION | |
|---|---|---|
| | | |




Indicate direction of view

Indiquer direction de prise de vue

| MAP NAME AND SCALE | NOM ET ECHELLE DE LA CARTE | |
|---|---|---|
| | | |

| GRID REFERENCE OF TARGET | COORDONNEES DU DISPOSITIF | |
|---|---|---|
| | | |

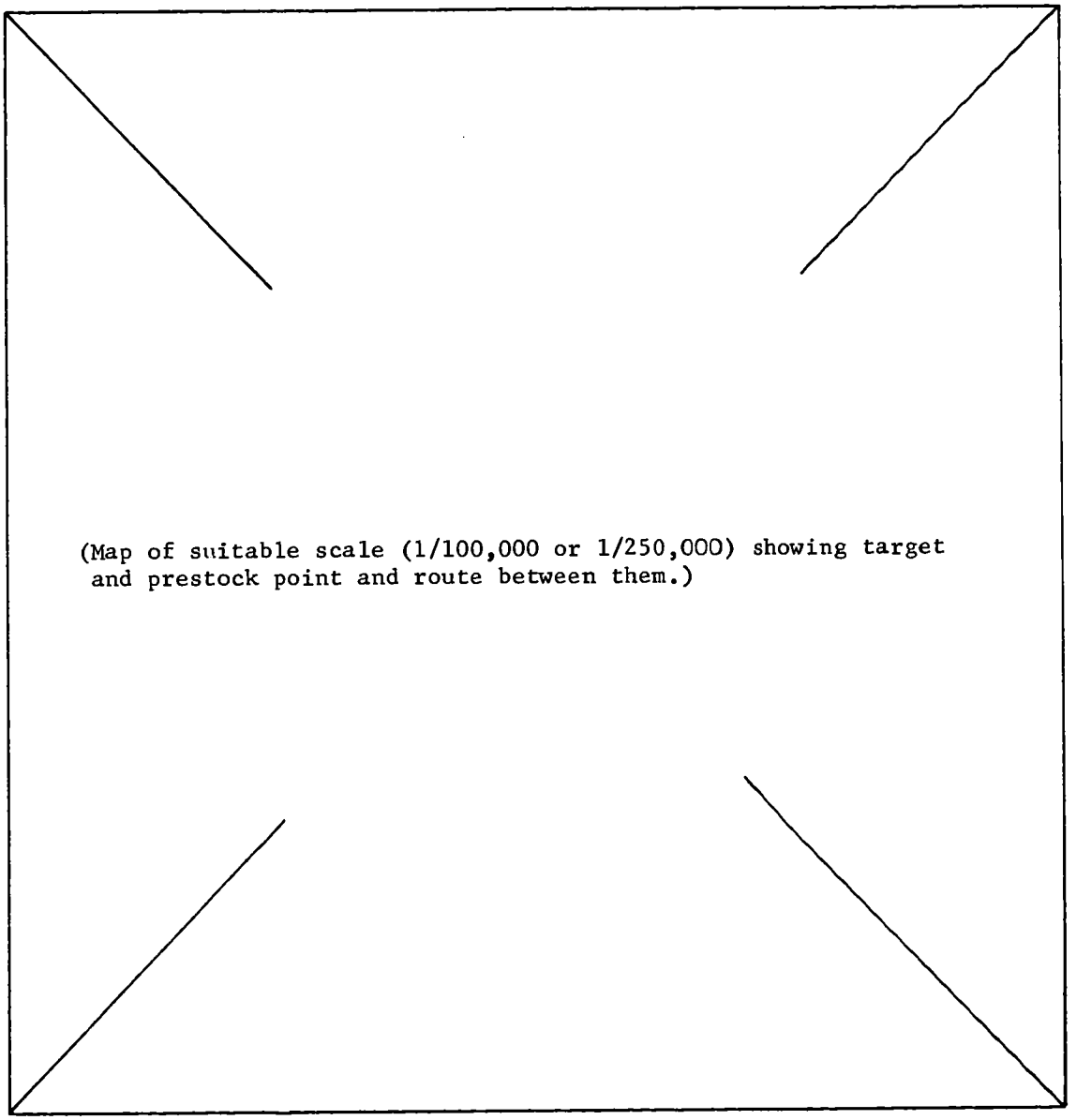
PAGE 2

(Security Classification)

*Figure 4-4*—Continued.

(Security Classification)

| (1a) LOCATION OF TARGET AND PRESTOCK POINT | EMPLACEMENTS DU DISPOSITIF ET DU CENTRE DE RATTACHEMENT (PRESTOCKAGE) | |
|---|---|---|




| SCALE | ECHELLE | |
|---|---|---|
| 1/_ _ _ _ _ _ _ _ _ _ _ _ | | |

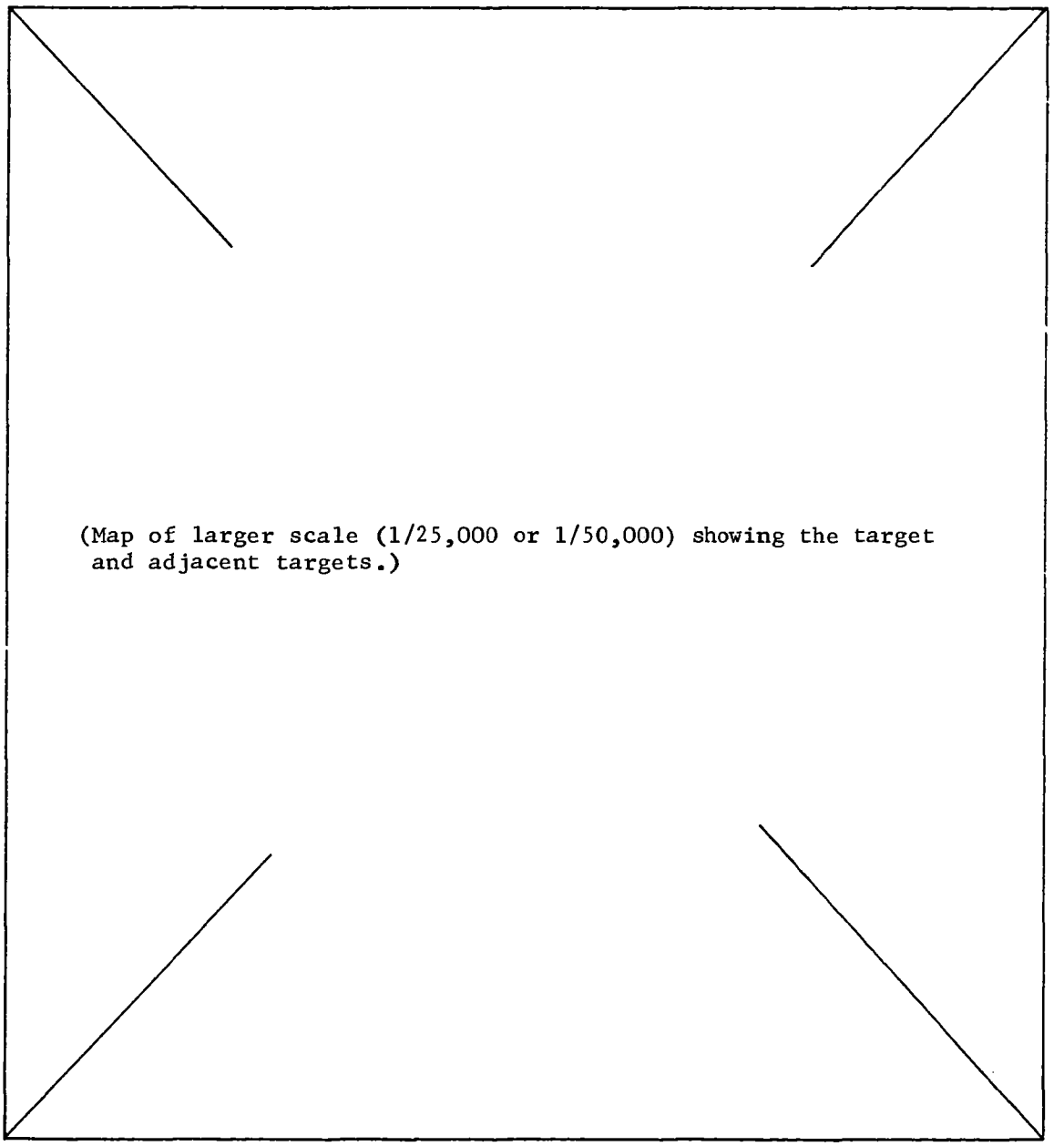
PAGE 3

(Security Classification)

*Figure 4–4*—Continued.

(Security Classification)

(1b) LOCATION OF TARGET | EMPLACEMENT DU DISPOSITIF | _____




| SCALE | ECHELLE | |
|---|---|---|
| 1/_ _ _ _ _ _ _ _ _ _ _ _ | | |

PAGE 4

(Security Classification)

*Figure 4–4*—Continued.

(Security Classification)

(2) SUPPLY OF EXPLOSIVES AND STORES FOR TARGET | APPROVISIONNEMENT DU CHANTIER DU DISPOSITIF | _____

1- PRESTOCK POINT: | CENTRE DE RATTACHEMENT (PRESTOCKAGE):

| NAME | NOM | |
|---|---|---|
| | | |

LOCATION: See maps pages 3, 6, 7. | EMPLACEMENT: Voir cartes pages 3, 6, 7.

2- TRANSPORT REQUIRED: | VEHICLES NECESSAIRES:

(Number) _____

TRUCKS of _____ Tons | CAMIONS de _____ Tonnes

3- ROUTE: See maps pages 3, 6, 7. | ITINERAIRE: Voir cartes pages 3, 6, 7.

4- Approximate travel DISTANCE from Prestock Point to Target: | DISTANCE approximative entre centre du rattachement (prestockage) et dispositif:

_____ km

5- Explosives and stores required: See page 8. | Explosifs et matériels nécessaires: Voir page 8.

PAGE 5

(Security Classification)

*Figure 4–4*—Continued.

(Security Classification)

| (2a) LOCATION OF PRESTOCK POINT | EMPLACEMENT DU CENTRE DE RATTACHEMENT (PRESTOCKAGE) | |
|---|---|---|

(Sketch map (scale of the order of 1/25,000) showing location and route.)

| SCALE | ECHELLE | |
|---|---|---|
| 1/_ _ _ _ _ _ _ _ _ _ _ _ | | |

PAGE 6

(Security Classification)

*Figure 4-4*—Continued.

(Security Classification)

| (2b) LAYOUT PLAN OF PRESTOCK POINT | PLAN DU CENTRE DE RATTACHEMENT (PRESTOCKAGE) | |
|---|---|---|

(Sketch map (scale about 1/5,000) showing entrances, route, storehouses(igloos) in which explosives and materials are stocked, etc.)

| SCALE | ECHELLE | |
|---|---|---|
| 1/_ _ _ _ _ _ _ _ _ _ _ _ | | |

PAGE 7

(Security Classification)

*Figure 4-4*—Continued.

(Security Classification)

(2c) EXPLOSIVES, STORES, MINES REQUIRED | EXPLOSIFS, MATERIELS, MINES NECESSAIRES | _____

| TARGET No. | DISPOSITIF No. | |
|---|---|---|
| | | |

| PRESTOCK POINT | CENTRE DE RATTACHEMENT | |
|---|---|---|
| | | |

| | ITEM (English) | DESIGNATION (Français) | | AMOUNT QUANTITE | TOTAL WEIGHT POIDS TOTAL |
|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) kg |
| 1 | EXPLOSIVES | EXPLOSIFS | | | |
| a | Cratering Charges | Expl. progres. | | | |
| b | High explosives | Expl. brisants | | | |
| c | Plastic explosives | Plastic | | | |
| d | Shaped charges | Charges creuses | | | |
| e | Cutting charges | Charges coup. | | | |
| 2 | ACCESSORIES | ARTIFICES | | | |
| a | Safety fuse | Mêche lente | | | |
| b | Detonating cord | Cordeau détonant | | | |
| c | Non-electric detonators | Amorce fulminante (détonateur pyrotechnique) | | | |
| d | Electric detonators | Amorce électrique (détonateur electrique) | | | |
| e | Blasting machine | Exploseur | | | |
| f | Cable electric (2 wire) | Cable électrique (2 fils) | | | |
| | | | | | |

PAGE 8

(Security Classification)

*Figure 4-4*—Continued.

(Security Classification)

| (1) | (2) | (3) | (4) | (5) | (6) kg |
|---|---|---|---|---|---|
| 3 | TOOLS | OUTILLAGE | | | |
| a | Quarrying bar | Barre à mine | | | |
| b | Shovels | Pelle | | | |
| c | Picks | Pieche | | | |
| d | Saws | Scie | | | |
| | | | | | |
| 4 | STORES | MATERIEL | | | |
| a | Nails | Pointes | | | |
| b | Wire | Fil de fer | | | |
| c | Timber | Planches | | | |
| | | | | | |
| 5 | MINES | MINES | | | |
| a | Mines AP | Mines AP | | | |
| b | Mines AT | Mines AC | | | |
| c | Fuzes | Allumeurs | | | |
| | TOTAL WEIGHT | POIDS TOTAL | | | |

PAGE 9

(Security Classification)

*Figure 4–4*—Continued.

(Security Classification)

(3) ORDERS TO THE COMMANDER, DEMOLITION FIRING PARTY

( Insert here "Orders to the Commander, Demolition Firing Party," Annex "B" to STANAG 2017, Edition 2.

- On Part I, para. 1.d., write: "See pages 11 ..... below."

- At the end of para. 13, add: "You will find a report format on Page 17 below.")

PAGE 10

(Security Classification)

*Figure 4–4*—Continued.

(Security Classification)

(3a) SPECIAL TECHNICAL INSTRUCTIONS | CONSIGNES TECHNIQUES PARTICULIERES

1- Time required for preparing and charging: | Temps nécessaire pour préparation et chargement:

| HOURS | HEURES | | MIN. |
|---|---|---|---|
| - - - - - | | | - - - - |

2- Time required for passing from State of Readiness 1 (SAFE) to 2 (ARMED): | Temps nécessaire pour passer de l'état de préparation 1 (NON AMORCE) à 2 (AMORCE):

| MIN. |
|---|
| - - - - - |

3- Personnel required for preparing and charging: | Personnel nécessaire pour préparation et chargement:

| | | | |
|---|---|---|---|
| N.C.O. | S/Officier | | - - - - - - - |
| Men | Hommes | | - - - - - - - |

4- Personnel required for firing: | Personnel nécessaire pour mise de feu:

| | | | |
|---|---|---|---|
| N.C.O. | S/Officer | | - - - - - - - |
| Men | Hommes | | - - - - - - - |

5- Organization of work (if necessary): | Organisation du chantier (si nécessaire):

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(Security Classification)

*Figure 4-4—Continued.*

(Security Classification)

| | |
|---|---|
| 6- Drawings and sketches: See pages 13, 14. | Plans et croquis: Voir pages 13, 14. |
| 7- MINES | MINES |
| a- Nuisance mines *MUST ) *MUST NOT )be laid. *See sketch page 16. | Des Mines de harcélement *DOIVENT ) être *NE DOIVENT PAS ) posées. *Voir croquis page 16. |
| b- THERE IS*(A) large *(NO) minefield near (give location and reference of minefield record). * Strike out words not applicable. | *IL EXISTE ) un *IL N'EXISTE PAS) champ de mines important à proximité (indiquer l'emplacement et documents de référence). * Rayer la mention inutile. |

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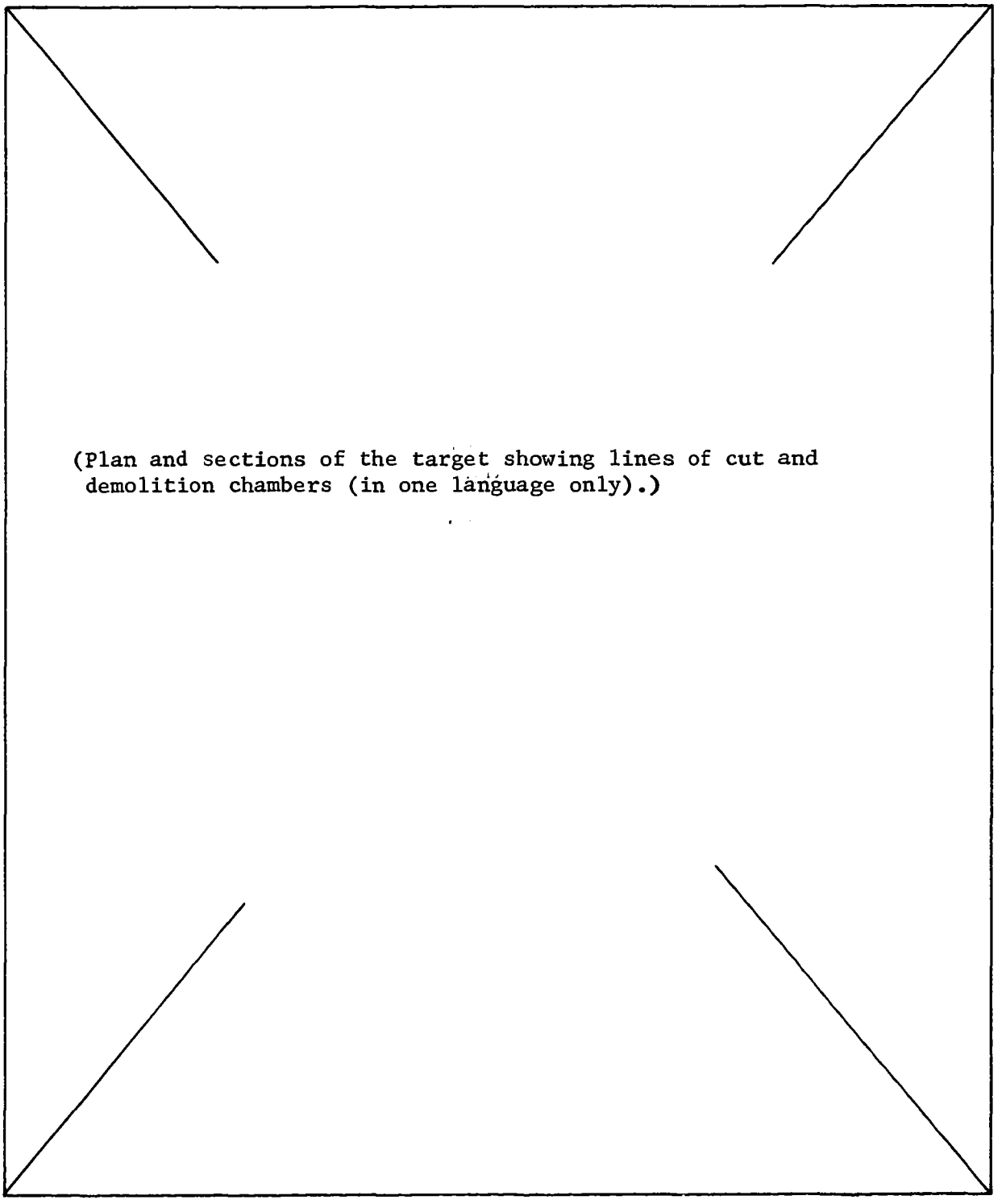
(Security Classification)

*Figure 4-4*—Continued.

(Security Classification)

(3b) SKETCH OF TARGET | CROQUIS DE L'OUVRAGE |

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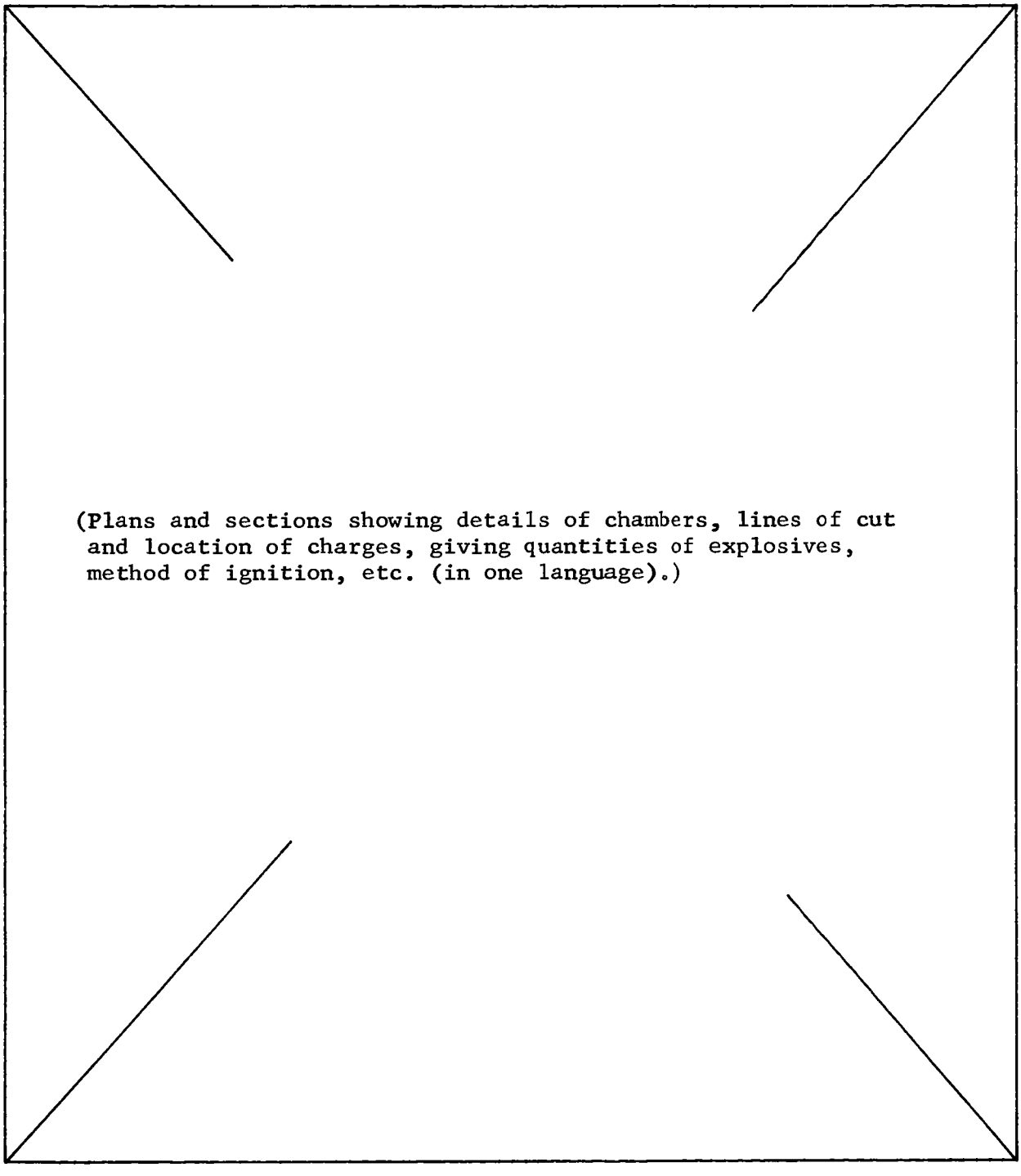
(Security Classification)

*Figure 4-4*—Continued.

(Security Classification)

(3c) SKETCH OF CHARGES | CROQUIS DE CHARGEMENT |

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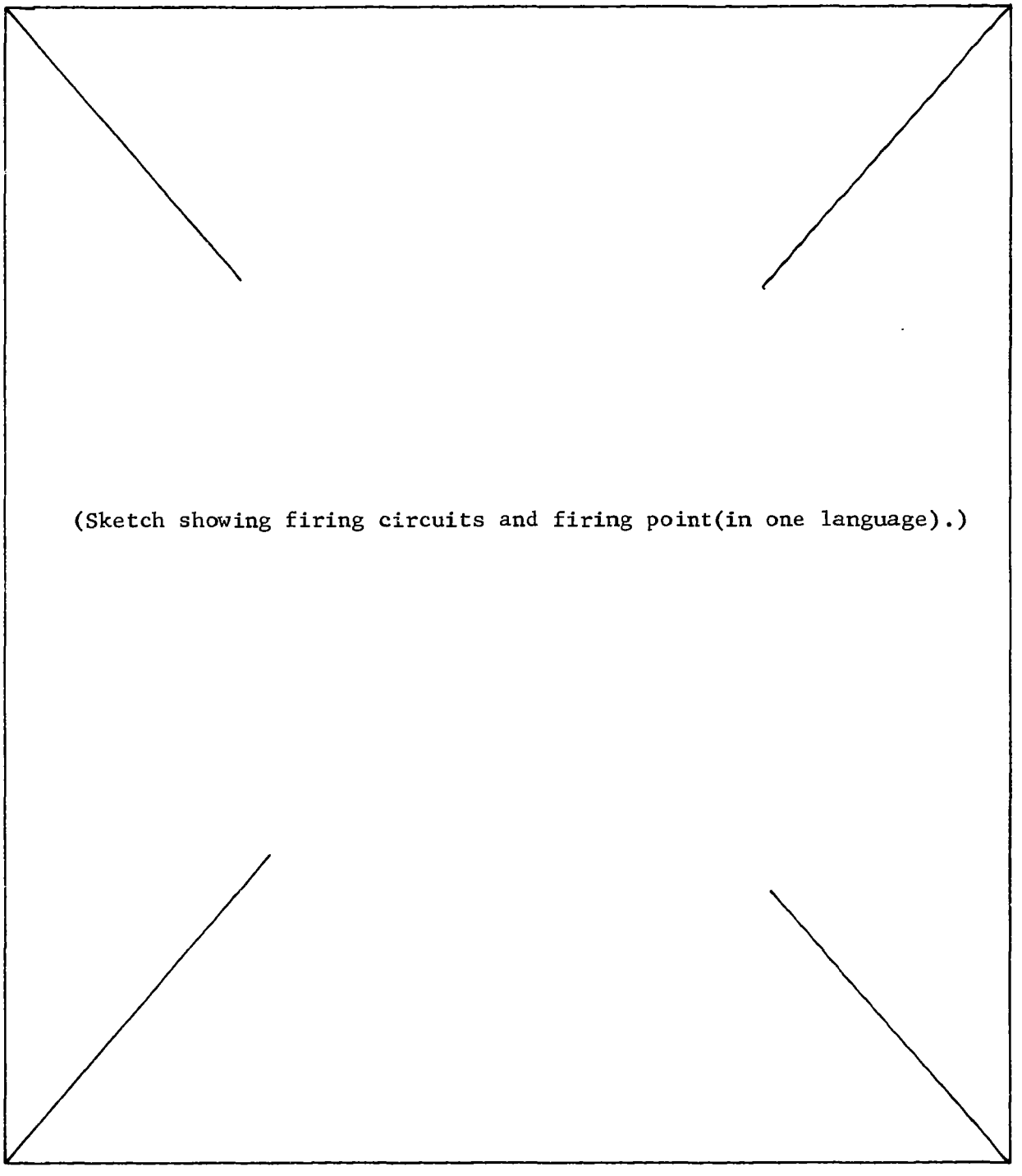
(Security Classification)

*Figure 4–4*—Continued.

(Security Classification)

| (3d) SKETCH OF IGNITION SYSTEM | SCHEMA DE LA MISE DE FEU | |
|---|---|---|

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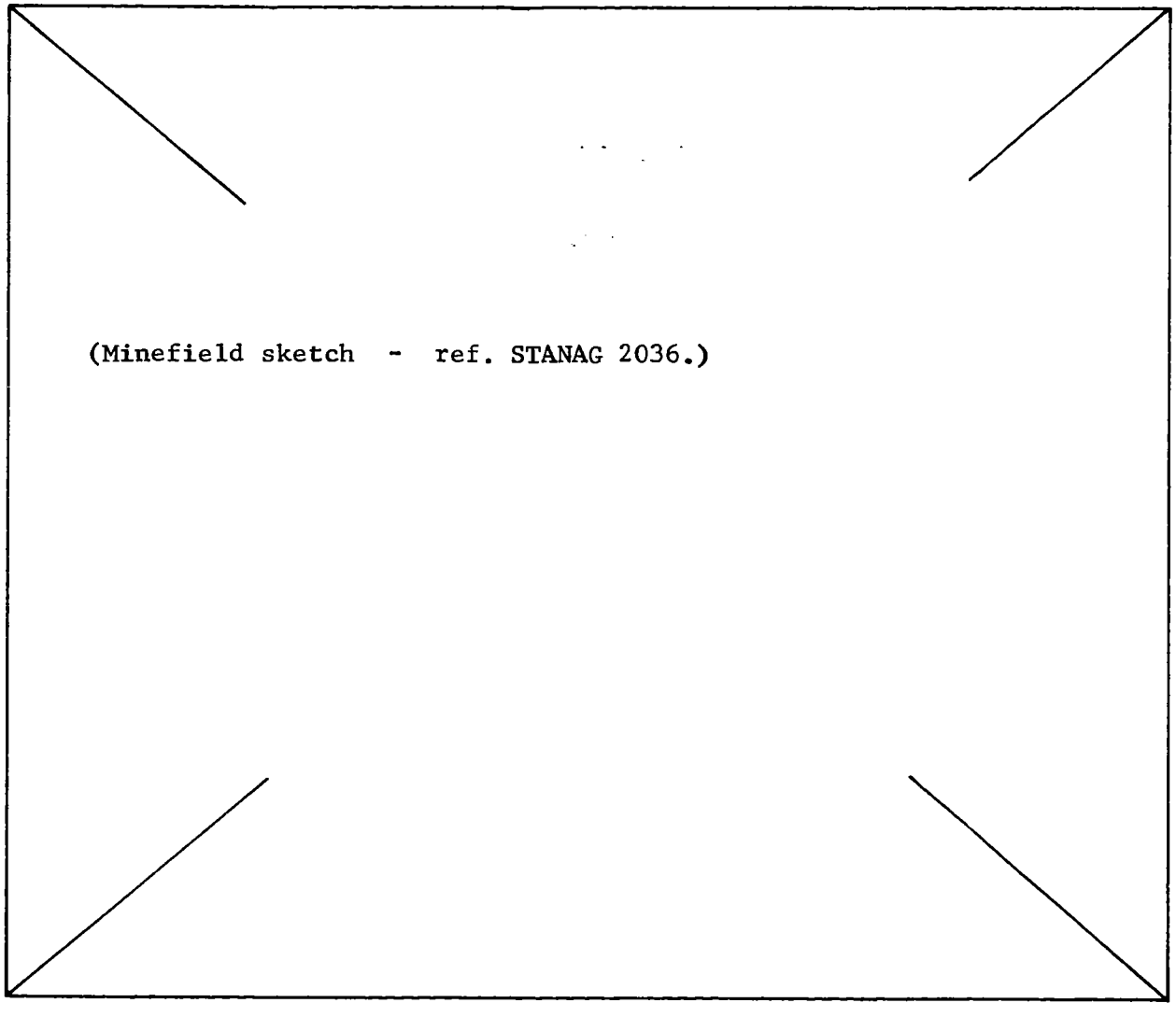
(Security Classification)

*Figure 4-4*—Continued.

(Security Classification)

| | | | |
|---|---|---|---|
| (3e) | NUISANCE MINE FIELD IF APPLICABLE, OR PROTECTIVE MINES | CHAMP DE MINES DE HARCELEMENT OU CHAMP DE MINES DE PROTECTION SUIVANT LE CAS | |
| | Personnel and time required for laying mines: | Personnel et temps nécessaire pour la pose des mines: | |

| Men | Hommes | | Hours | Heures | | Min. |
|---|---|---|---|---|---|---|
| | | | | | | |

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(Security Classification)

*Figure 4-4*—Continued.

(Security Classification)

(4) DEMOLITION REPORT | COMPTE RENDU DE DESTRUCTION

| | | | | |
|---|---|---|---|---|
| a- | DEMOLITION No. | DISPOSITIF No. | | _ _ _ _ _ |
| b- | MAP REFERENCE | COORDONNEES | | _ _ _ _ _ |
| c- | Demolition was fired at | La mise de feu a été faite à | | |

| DATE-TIME | DATE-HEURE | |
|---|---|---|
| | | |

d- EXTENT OF DAMAGE | RESULTATS OBTENUS

(1) In case of a bridge | (1) Cas d'un pont

| | | |
|---|---|---|
| Width of gap _ _ _ _ meters | Largeur de breche _ _ _ _ _ mètres | |
| No. of spans down _ _ _ _ _ _ _ _ | No. de travées détruites _ _ _ _ _ | |

(2) In a road or runway: size, depth and location of craters: | (2) Sur une route ou piste: Dimensions, prefondeur et emplacement des entonnoirs:

(3) Mines laid, type and number: | (3) Mines posées, type et nombre:

(4) Any other details: | (4) Autres renseignements:

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(Security Classification)

*Figure 4–4*—Continued.

(Security Classification)

| (5) SKETCH showing effect of demolition | CROQUIS montrant les effets de la destruction | |
|---|---|---|

| Date-Time | Date-Heure | |
|---|---|---|
| | | |

| Name | Nom | | Rank | Grade | Unit | Unité |
|---|---|---|---|---|---|---|
| | | | | | | |

| TO | DESTINATAIRE | |
|---|---|---|
| | | |

| SIGNATURE | |
|---|---|
| | |



(Security Classification)

*Figure 4-4*—Continued.

(Security Classification)

NOTES
1. The maps showing the "Location of the target and prestock point" (page 3), "Location and layout plan of prestock point" (pages 6 and 7), and the "List of explosives and stores" (pages 8 and 9) can be detached from the folder and handed to the commander of the party detailed to collect the explosives and stores from the prestock point.
2. Use the special format on page 17 and 18 for the demolition report. Paragraphs a and b should be completed by the unit/agency responsible for the preparation of the folder.

---

OBSERVATIONS
1. Les cartes "Emplacements du dispositif et du centre de rattachement" (page 3), "Emplacement et plan du centre de rattachement" (pages 6 et 7), et la "Liste des explosifs et matériels" (pages 8 et 9) peuvent être retirées du carnet pour être remises au Chef de détachement chargé d'aller chercher les explosifs se matériels au centre de rattachement (préstockage).
2. Pour le compte rendu d'exécution utiliser la feuille ad hoc page 17, dont les paragraphes a et b auront été complétés par l'autorité chargée de l'établissement du carnet.

---

TARGET folder completed by: Carnet d'ALERTE établi par:

| Name | Nom | | Rank | Grade | Designation | Function |
|---|---|---|---|---|---|---|
| | | | | | | |

| Signature | |
|---|---|
| | |

| Date | |
|---|---|
| | |

Checked by: Contrôlé par:

| Name | Nom | | Rank | Grade | Designation | Function |
|---|---|---|---|---|---|---|
| | | | | | | |

| Signature | |
|---|---|
| | |

| Date | |
|---|---|
| | |

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(Security Classification)

*Figure 4-4*—Continued.

## Section II. TECHNIQUES COMMON TO MOST DEMOLITIONS

### 4–8. Types of Military Demolitions

There are three types of demolitions applicable to tactical situations—reserved, deliberate, and hasty.

*a. Reserved Demolitions.* These are specifically controlled at a command level appropriate to the tactical or strategic plan. Reserved demolitions are usually in place, "ready and waiting," in the "safe" condition.

*b. Deliberate Demolitions.* Deliberate demolitions are used when enemy interference during preparations is unlikely and there is sufficient time for thorough reconnaissance and careful preparation. Deliberate preparation permits economy in the use of explosives, since time permits accurate calculation and positive charge placement to obtain the effects required.

*c. Hasty Demolitions.* Hasty demolitions are used when time is limited and economy of explosives is secondary to speed. In all cases, common sense and good judgment must be exercised to prevent waste. In the preparation of demolition projects in forward areas where a surprise raid by hostile forces is possible, a priority should be given to each charge. Although this procedure is relatively time consuming, it causes maximum damage in relation to the time required, even though enemy interference might prevent completion of the job. Each charge is primed as it is placed; for if charges are all placed first and then primed, it is possible that enemy interference prior to the act of priming might stop the work before any damage is done. The use of dual detonating cord ring main lines and branch lines is recommended for all frontline demolition projects (para 2–13—2–16).

### 4–9. Nuclear Weapons Demolitions

Atomic demolition munitions (ADM) may be effectively employed to create obstacles and to destroy and deny military facilities or installations. They have the capability of creating large radioactive craters with little preparatory effort. The residual radiation and fallout hazards require consideration; however, the use of small yields minimizes the fallout hazard and area of residual contamination. The ADM, like conventional hand-placed charges, has a primary advantage over ballistic-delivered explosives, thus permitting the use of minimum yield for a given target. For further information see FM 5–26.

### 4–10. Supplementing Demolition Obstacles

Nuisance mining and charges with delay fuses are very potent means of increasing the effects of demolition projects. The area to be mined should include the facility to be destroyed, the ground where a replacement structure or remedial work will likely be performed, working party bivouacs, and alternate sites. Thus, for a demolished bridge, the dropped spans and abutments should be mined to impede removal or recovery; suitable sites for a floating bridge or ford should be mined to prevent ready use; and locations likely to be selected for material storage, equipment parks, or bridge unit bivouacs should also be well mined and boobytrapped. For further information see FM 20–32.

## Section III. BRIDGE DEMOLITION

### 4–11. Extent of Demolition

There is no rule of thumb or regulation to indicate the optimum extent of demolition of bridges. It is determined after investigation and analysis of specific conditions.

*a. Complete Bridge Demolition.* Complete demolition leaves nothing of the old bridge suitable for use in a new bridge. Debris is left on the site where its removal will require much hazardous work before any kind of crossing can be installed. However, when enough demolition is accomplished to force the enemy to select another site for a temporary bridge as a substitute for the damaged bridge, further demolition is unnecessary. Too, a permanent structure is not likely to be replaced in kind during wartime. However, where the terrain is such that the existing bridge site is needed for a new structure, even a temporary one, demolition in greater proportions may be justified.

*b. Partial Demolition.*

(1) *Method.* Bridges are generally demolished to create obstacles that delay the enemy. This seldom requires complete destruction. Unless a denial operation is in effect, the demolition method chosen should permit the economical reconstruction of the bridge by friendly troops at a later date. Frequently the necessary delay can be obtained by only blasting a gap too long to be spanned by the prefabricated bridging available

to the enemy. This gap should be located where the construction of an intermediate support is difficult or impossible. A high and relatively slender bridge component may be demolished by cutting one side so that it topples into a mass of broken and twisted material. The destruction of massive bridge components, however, requires large expenditures of explosive, time, equipment, and effort that may not be profitable. In many cases on major bridges, the destruction of any component that can easily be replaced may not be justified.

(2) *Factors determining the extent of demolition.* Factors that determine the extent of bridge destruction are the same as listed in paragraph 4–5.

## 4–12. Planning Bridge Demolitions

*a. Structural Characteristics.* The demolition of bridges must be carefully planned, as there are many types of bridges having a great variety of superstructures made of steel, timber, or masonry and various types of substructures made of these materials. The size and placement of the charge, therefore, depends on the characteristics of the individual bridge structure.

*b. General Procedures.* Some general procedures apply to most bridge demolition projects; for example: if charges are placed under the bridge roadway, special precautions must be taken to insure that the charges will not be shaken loose or initiated by traffic on the bridge. The following general points apply to the demolition of most or all of the bridge structures mentioned and described below.

(1) Hasty charges, which must be placed first because of enemy interruption, should be located carefully, if possible, so that they may be included later on into the deliberate preparation of the bridge.

(2) It is often possible either to economize on the use of explosives or to improve the thoroughness of the demolition by blasting several times rather than only once. When conditions permit, this procedure should be considered.

(3) Tension members are more difficult to repair than compression members, because the latter may sometimes be replaced by cribbing while the former almost always require steel riveting or welding. Thus tension members should be given priority.

(4) When bridges over railways or canals are to be destroyed, the demolition should be so planned that any temporary intermediate piers that might be erected to repair the structure will be located where they will block traffic on the railroad or canal.

(5) Any long steel members that require cutting in only one place to demolish the bridge should be further damaged to prevent their ready salvage by recutting or splicing. It is not necessary to cut such members completely in two at other points to accomplish this. A number of small charges properly located will damage the upper flange, the lower flange, and the web, which will make repair difficult and uneconomical. The twisting of such members in dropping the span and any other feasible method of further destruction should also be considered.

(6) The nature of the terrain under the bridge is of great importance to the success of the demolition. If the distance from the river bed, for example, to the bridge is adequate, the weight of the bridge may be exploited to assist in its destruction (fig 4–19).

## 4–13. Types of Bridges

Bridges may be classified in many different ways. For the purpose of planning and executing bridge demolitions, bridges are grouped into three general types; fixed bridges, movable bridges, and floating bridges.

*a. Fixed Bridges.* Fixed bridges are those in which a rigid and nonmovable superstructure is supported on solid and nonmovable supports. Fixed bridges are the most common type of bridges.

*b. Movable Bridges.* Movable bridges are those in which a portion of the bridge is capable of being moved to allow waterborne traffic to pass the bridge.

*c. Floating Bridges.* Floating bridges have a roadway which is supported by floats or pontoons. This type of bridge is usually constructed by military forces and is used as a temporary bridge until a fixed or movable bridge is completed or repaired.

## 4–14. Parts of Bridges

The ordinary bridge is divided into two main parts: the lower part or substructure, and the upper part or superstructure (fig 4–5).

*a. Substructure.* The substructure consists of the parts of the bridge that support the superstructure. There are two kinds of supports: end supports or abutments and intermediate supports, or piers or bents. The parts of the substructure are—

(1) *Abutment.* The ground supports at the ends of a bridge are called abutments. These may be constructed of concrete, masonry, steel, or timber and may include retaining walls or an end dam.

(2) *Footing.* A footing is that part of any bridge support that rests directly on the ground. It distributes the load over an area wide enough to keep the support from sinking into the ground.

(3) *End dam.* An end dam is a retaining wall of concrete, wood, or other material at the end of a bridge that supports the bank and keeps the approach road from caving in.

(4) *Intermediate support.* An intermediate support is a support placed beneath a bridge between the abutments. It may be a pier of masonary or concrete, cribbing, several pile or trestle bents constructed as a unit, or a single pile or trestle bent.

(5) *Pontoon.* A pontoon is an intermediate support which floats on the water. It is found in floating bridges.

*b. Superstructure.* The superstructure includes the flooring, stringers, floor beams, and any girders or trusses that make up the total part of the brdige above the substructure (fig 4–5).

(1) *Stringers.* Stringers run longitudinally with the bridge and directly support the deck.

(2) *Girders.* Girders are defined as two large stringers which run longitudinally and are the main load-carrying members.

(3) *Trusses.* Trusses are built-up members which are the load-carrying members of the superstructure and consist of these principal elements:

(*a*) *Lower chord.* The lower chord is the lower member in a panel of a truss that runs parallel to the deck.

(*b*) *Upper chord.* The upper chord includes the upper members in a truss panel.

(*c*) *Intermediate chord.* The intermediate chord or diagonals are the members between the upper and lower chords.

(4) *Deck and tread.* The deck is the floor of the bridge and the tread, the top surface material.

## 4–15. Destruction of Substructures

*a. Concrete and Masonry Abutments.*

(1) *Charges in fill behind abutment.* The

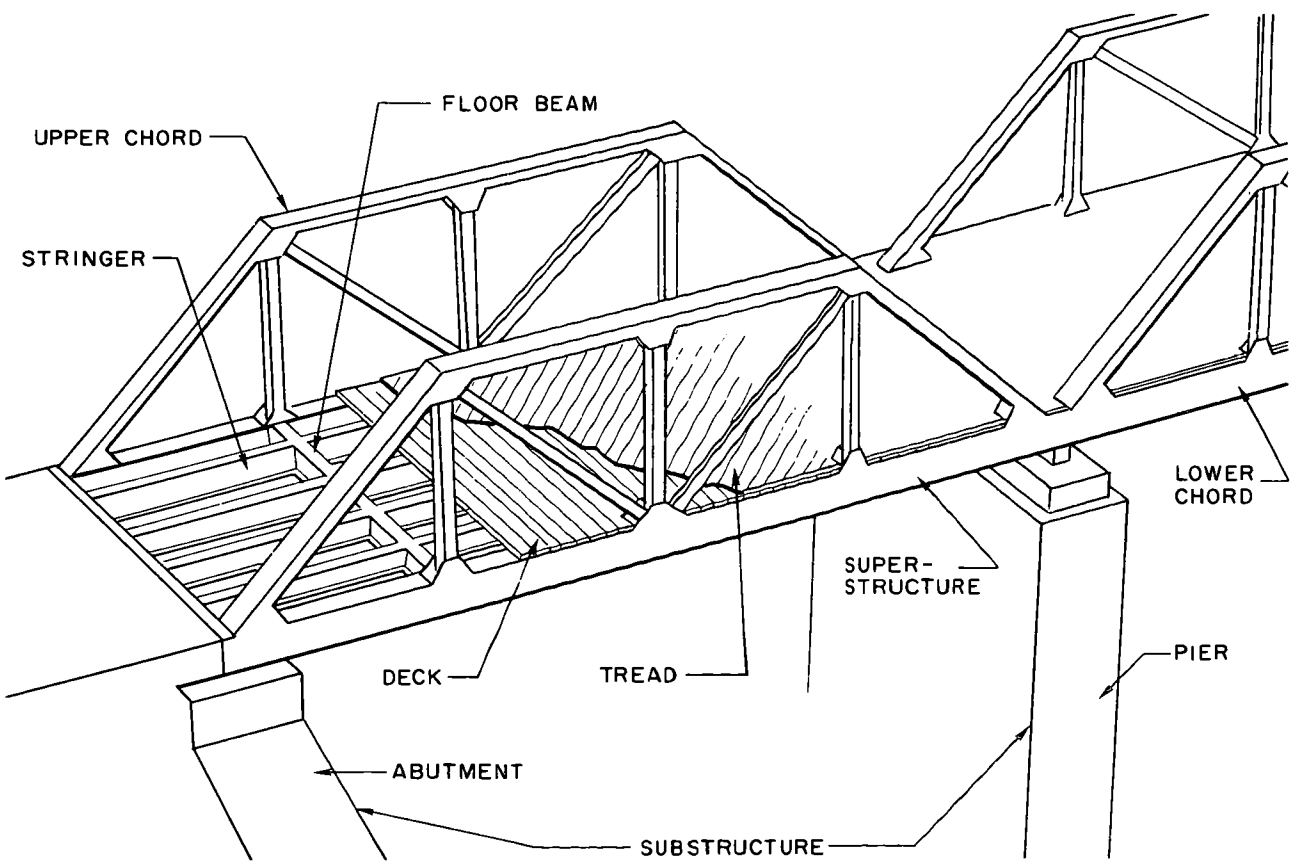



*Figure 4–5. Parts of a bridge.*

placing of charges in the fill behind an abutment has the advantages of economy in the use of explosives and of concealment of the charges from the enemy until they are detonated. This method also has its disadvantages, as the charges are difficult to place. Where speed is required, charges are not placed behind the abutment if the fill is known to contain large rocks.

(2) *Abutments 5 feet or less in thickness.* Such abutments are demolished by a line of 40-pound cratering charges placed on 5-foot centers in holes 5 feet deep and 5 feet behind the face of the abutment ("triple-nickel-forty"). The first hole is placed 5 feet from one side of the abutment and this spacing is continued until a distance of 5 feet or less is left from the last hole to the other side of the abutment. If the bridge approach is an embankment, the more practical method may be to place the explosive charges in a tunnel dug into the side of the embankment. The formula for computing the number of charges is $N = \frac{W}{5} - 1$, where $N$ = number of charges and $W$ the width of abutment. If the wing walls are strong enough to support a rebuilt or temporary bridge, they too should be destroyed by placing charges behind them in a similar fashion. (fig 4–6)

(3) *Abutments more than 5 feet thick.* Such abutments are destroyed by breaching charges placed in contact with the back of the abutment. The breaching radius is the thickness of the abutment. The charges are placed at a depth equal to the breaching radius (fig 4–7).

(4) *Abutments over 20 feet high.* If the abutments are over 20 feet in height, in addition to the charges in (2) or (3) above place a row of breaching charges at the base of the abutment on the river face. All charges should be fired simultaneously. These fill charges may be breaching charges as explained in (3) above, or the "triple-nickel-forty" charges depending on the abutment thickness. This tends to overturn and completely destroy the abutment. The breaching charges are calculated by means of the breaching formula, $P = R^3KC$ (para 3–12), using the abutment thickness at the charge location as the breaching radius $R$. The charges are placed at a depth equal to or greater than $R$. The number of charges and their spacing are determined by the formula $N = \frac{W}{2R}$.

*b. Intermediate Supports.*

(1) *Effectiveness.* The destruction of one or more intermediate supports of a multispan bridge is usually the most effective method of demolition (fig 4–8). The destruction of one support

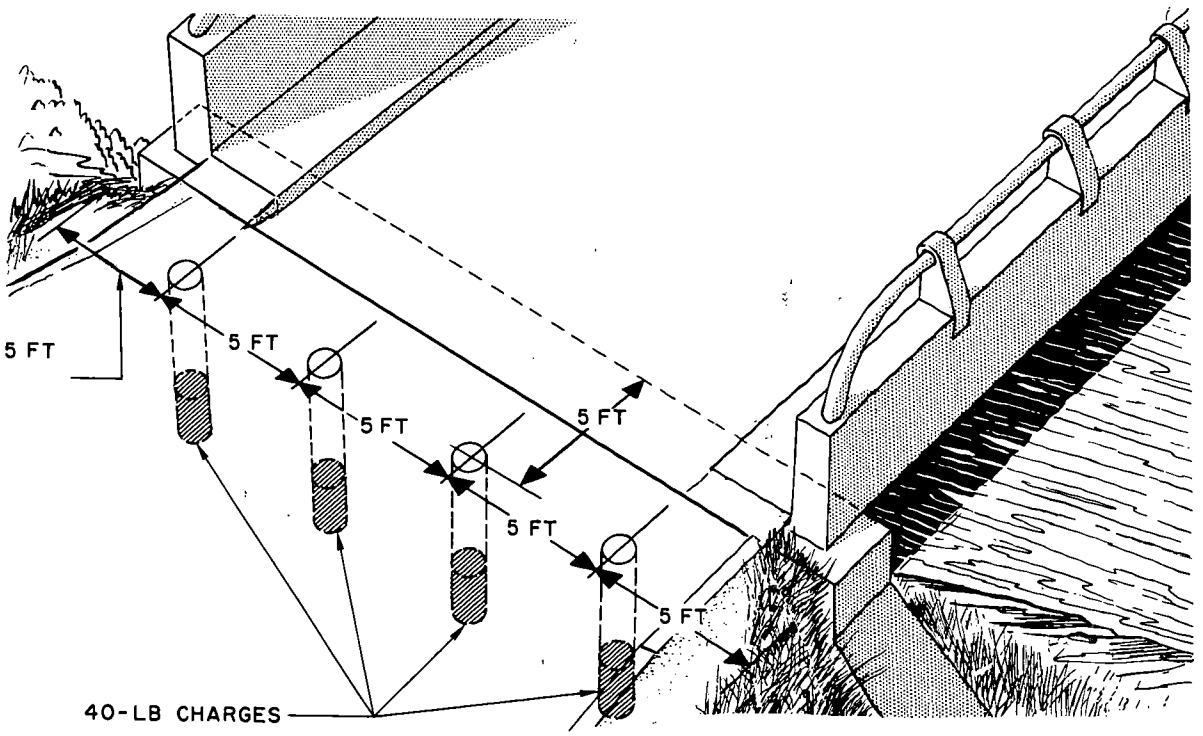



*Figure 4–6. Destruction of abutment 5 feet thick or less.*

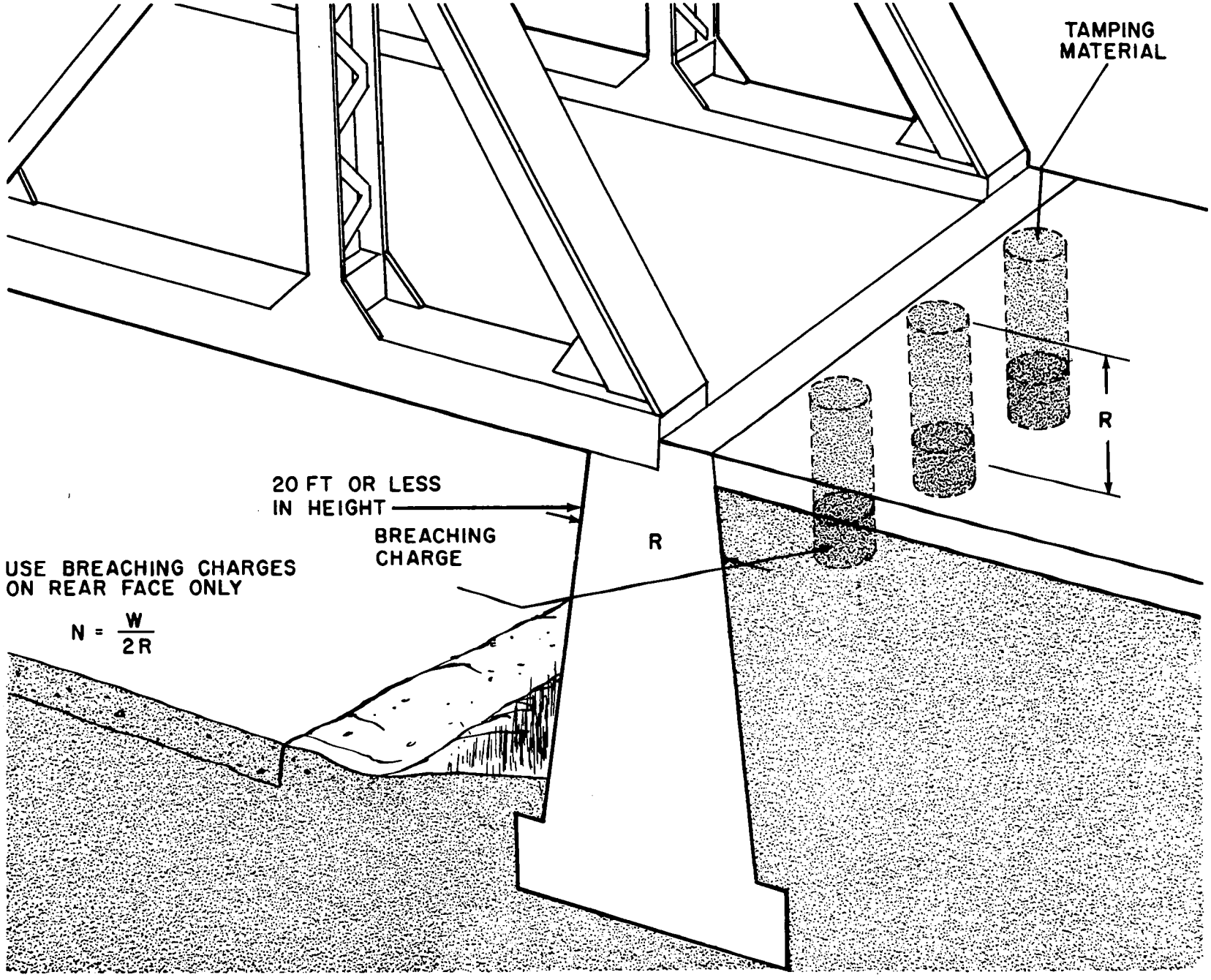


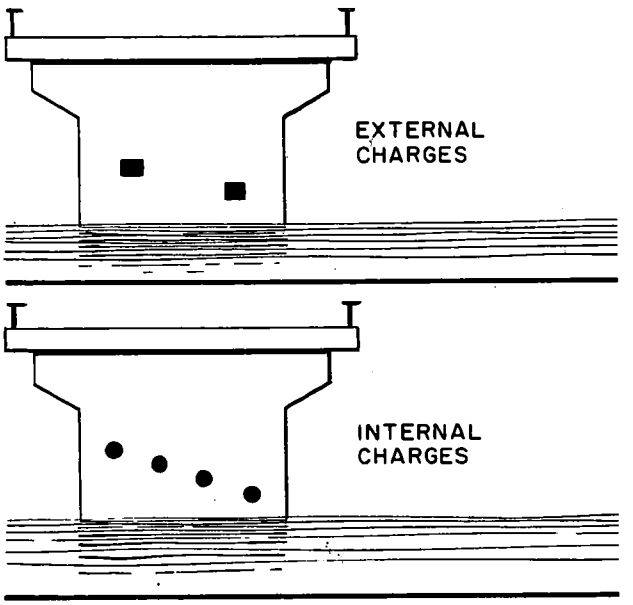

*Figure 4–7. Destruction of abutment more than 5 feet thick.*

will usually collapse the spans on each side of it, so that destruction of only alternate intermediate supports is sufficient to collapse all spans. For repair this will require either the replacement of those supports or the construction of long spans.

(2) *Concrete and masonry piers.* Concrete and masonry piers are demolished either by internal or external charges (fig. 4–8). Internal charges requires less explosive than external charges, but because they require a great amount of equipment and time for preparation, they are seldom used unless explosives are scarce or the pier has built-in demolition chambers. The number of charges required is calculated by the formula $N = \frac{W}{2R}$ (para 3–13). The size of each charge is calculated by the breaching formula, $P = R^3KC$ (para 3–12).

(*a*) *Internal charges.* Plastic (C3 or C4), dynamite, and other explosives are satisfactory for internal charges. All charges of this type should be thoroughly tamped with blunt wooden tamping sticks, *not* with steel bars or tools. If there are no demolition chambers, charges are placed in boreholes, which are blasted by means of shaped charges or drilled with pneumatic or hand tools. A 2-inch diameter borehole holds about 2 pounds of explosive per foot of length or depth. The steel reinforcing bars, however, make drilling in heavily reinforced concrete impractical.

(*b*) *External charges.* External charges may be placed at the base of a pier or higher and spaced not more than twice the breaching radius (para 3–12) apart. All external charges should be thoroughly tamped with earth and sandbags if time and the size, shape, and location of the target permit.



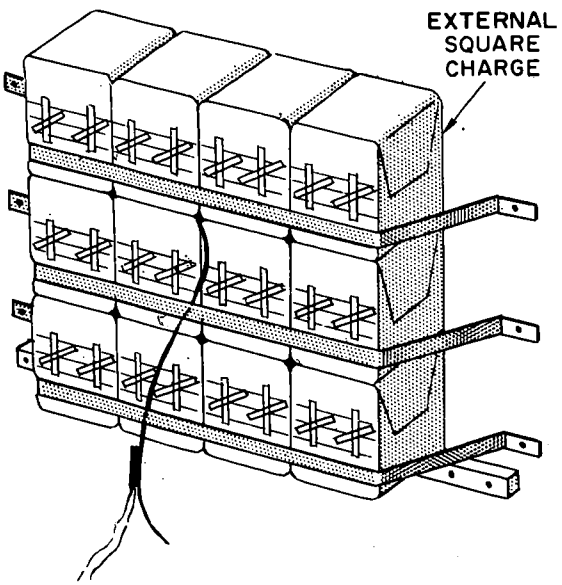




*Figure 4–8. Charges placed on intermediate supports.*

## 4–16. Destruction of Superstructures

*a.* In the destruction of bridge superstructures the material from which the load-bearing members are made is as important as the type of superstructure, in that the material used often determines the types of superstructures which may be built.

*b.* The methods for destruction or cutting of the most common types of superstructures are given in paragraphs 4–17 through 4–25.

## 4–17. Timber Stringer Superstructures

*a.* Timber stringer bridges are used extensively in the theater of operations for short span crossings or a multiple of short spans for longer crossings. These bridges normally are constructed and utilized by the military. The stringers may consist of native timber logs or cut, dimensioned timber. The spans are simply supported and rarely exceed 20 feet. The deck normally is either plank or laminated, timber decking. Some civilian bridges may have asphalt or concrete wearing surfaces.

*b.* Timber stringer superstructures are cut by placing timber cutting charges to cut each stringer as shown in figure 4–9.

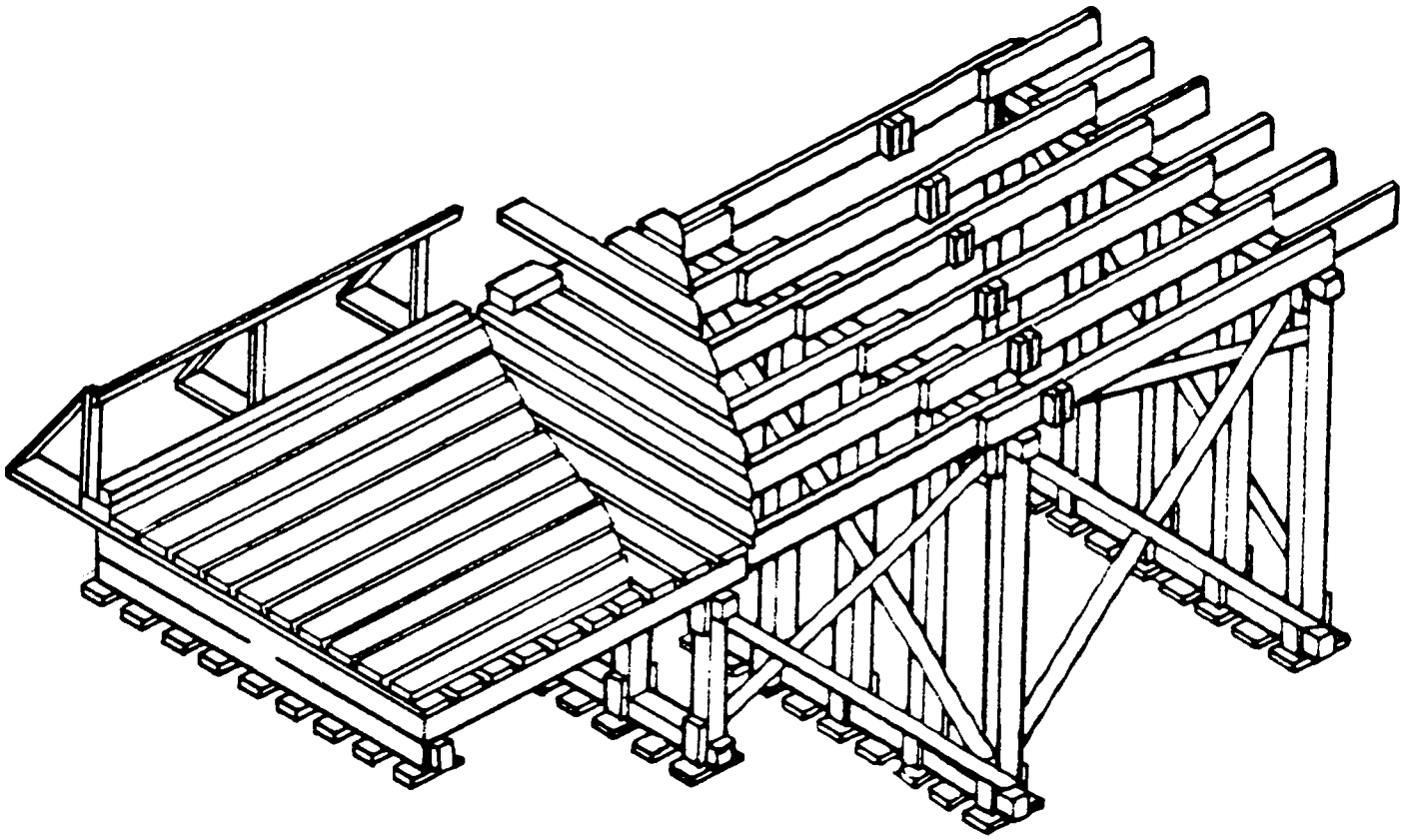


*Figure 4–9. Demolition of timber stringer superstructures.*

## 4–18. Steel Stringer Superstructures

*a.* Steel stringers are used in simply supported spans up to 90 feet and in continuous span bridges with clear spans up to 120 feet. The nonstandard steel stringer bridge is frequently constructed in the theater of operations by the military. Most civilian steel stringer bridges constructed since the mid 1950's utilize high strength steel and concrete and improved design techniques. Steel stringers consist of standard rolled shapes in spans up to 90 feet and beams built up with welded steel plate in the 60- to 120-foot span range.

*b.* Steel stringer superstructures are cut by placing steel cutting charges to cut each stringer, as shown in figure 4–10.

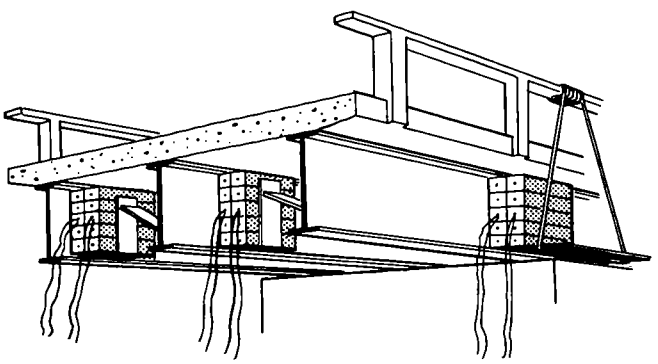


*Figure 4–10. Demolition of steel stringer superstructures.*

## 4–19. Composite Steel–Concrete Stringers

*a.* In the early 1960's, efficient means were developed to connect the reinforced concrete deck to the top flange of steel stringers. In normal steel stringer bridges, the concrete deck serves only to distribute the live load to the stringers. When the deck and stringer are structurally connected a composite steel-concrete beam is formed. The concrete deck increases the compression flange of the stringer. Composite beam bridges are difficult to recognize or distinguish from a normal steel stringer bridge. All steel stringer concrete deck bridges with over 60 feet clear span constructed after the mid 1960's, can be assumed to be composite beam.

*b.* Composite steel-concrete stringer superstructures are cut by placing steel cutting charges and concrete breaching charges to cut each steel

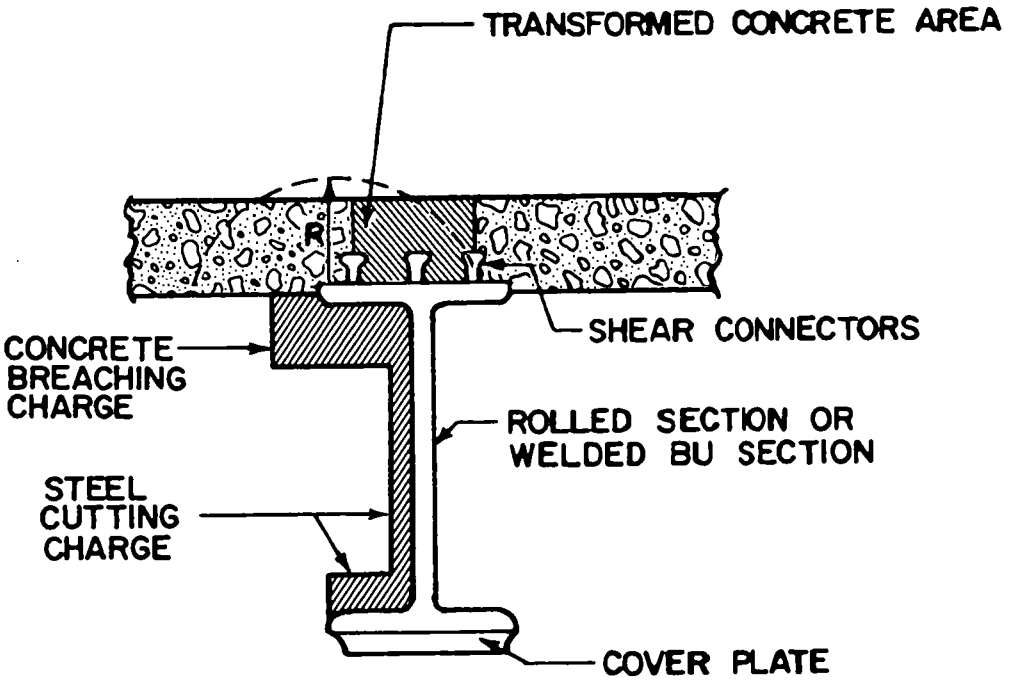



*Figure 4–11. Charge placement on composite steel-concrete stringer.*

stringer and breach the concrete deck above each stringer as shown in figure 4–11.

### 4–20. Steel Girder Superstructures

*a.* Steel girders are generally used for spans of 100 feet to 350 feet. The girder is used in spans too long for standard rolled shapes. The girder bridge referred to in this discussion consists of two large built-up flexural members that support the roadway, as opposed to the stringer bridge that may have many equally spaced smaller girders or stringers. Girder bridges normally are of continuous construction and frequently the girder is haunched (deepened) over the intermediate supports.

*b.* Steel girder superstructures are cut by placing steel cutting charges to cut each girder.

### 4–21. Reinforced Concrete Slab Superstructures

*a.* The concrete slab superstructure is an efficient structure for short spans up to 25 feet. Multispan slab bridges normally are continuous over intermediate supports. Span lengths for continuous slab bridges rarely exceed 40 feet.

*b.* Reinforced concrete slab superstructures are demolished by placing breaching charges across the width of the slab to breach it (fig 4–22).

### 4–22. Reinforced Concrete T-Beam Superstructures

*a.* Reinforced concrete T-beam superstructures are normally used in simply supported spans of 30 to 60 feet and in continuous spans up to 100 feet. Continuous span bridges normally employ variable depth T-beams to provide a greater beam depth over the intermediate supports.

*b.* Reinforced concrete T-beam superstructures are demolished by placing charges to cut each beam using one of the following methods (fig 4–12):

(1) Place concrete breaching charges against the side of each beam.

(2) Place concrete breaching charges against the bottom of each beam.

(3) Place pressure charges (para 3–10) on the deck (roadway) above each beam.

(4) Place breaching charges on the deck above each beam.

### 4–23. Prestressed Concrete Beam Superstructures

*a.* Prestressed concrete beam superstructures are basically concrete stringer superstructures utilizing high-strength steel and concrete. They are similar to reinforced concrete T-beam superstructures but may be recognized by the I-

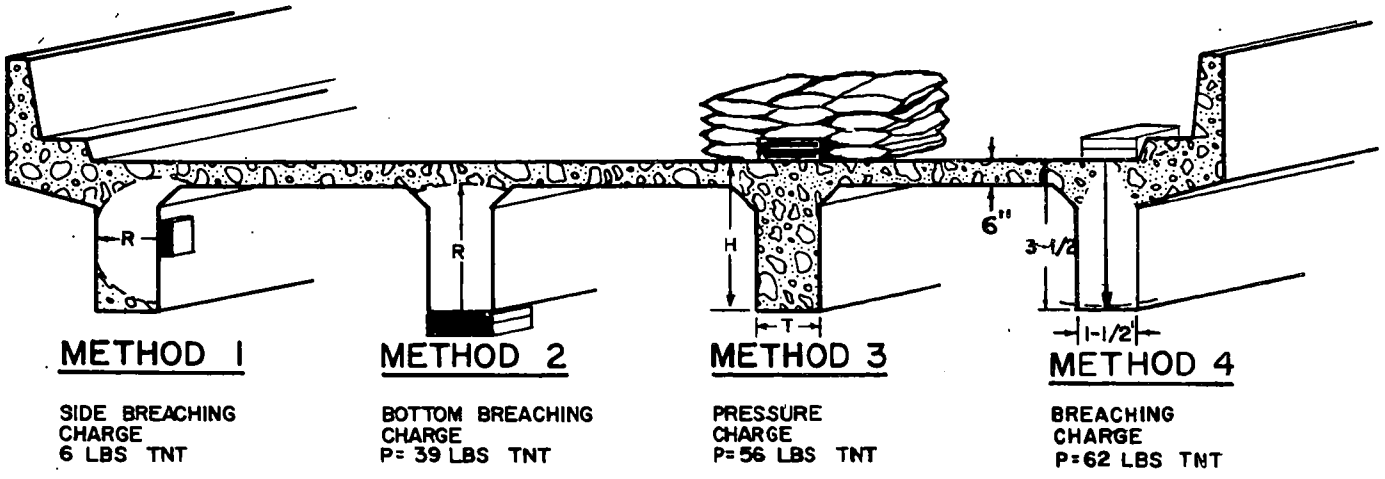



*Figure 4–12. Demolition of reinforced concrete T-beam superstructures.*

shaped concrete beam (fig 4–13). Spans may be simply supported or continuous. Spans up to 200 feet in length are in use.

*b.* Prestressed concrete beam superstructures may be demolished by one of the following methods (fig 4–13):

(1) Place dual concrete breaching charges on one side of the beam against the sloped sides of the top and bottom flanges of each beam with charges butted against the junction of the web and flanges to destroy the beam.

(2) Place M2A4 or M3A1 shaped charges over the top or against the bottom of each beam to cut the beam.

*c.* Pressure charges placed on top of prestressed concrete beams are not effective.

## 4–24. Concrete Box Beam Superstructures

*a.* Hollow concrete box beam superstructures are of two types; the precast box beam and the large monolithic hollow box girder.

(1) The precast box beams are individual beams 3 feet wide, laid adjoining each other and held together by transverse diaphram rods. Joints between adjoining beams are grouted. These are used extensively in foreign countries, and generally for simple spans 40 to 60 feet in length.

(2) The large cast-in-place hollow box girder is generally used in continuous spans 60 to 160 feet in length. These superstructures may have an access door to allow entry into the beams.

*b.* Precast concrete box beams superstructures may be cut by placing concrete breaching

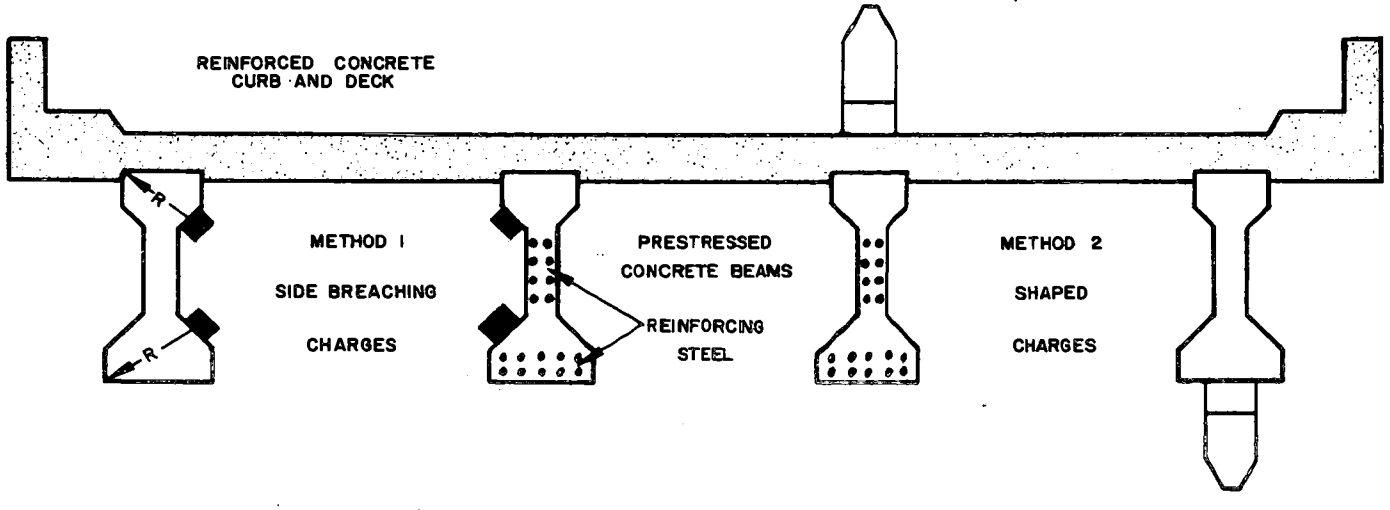



*Figure 4–13. Demolition of prestressed concrete beam superstructures.*

charges (calculated for reinforced concrete) against the bottom of each beam, centered over the sides of the beam to cut the bottom and sides of each beam. Charges should be placed at least one breaching radius away from the internal concrete diaphrams (determined by location of transverse steel rods).

*c.* Hollow concrete box girder superstructures are demolished by placing charges to cut the bottom and/or sides of each box girder using one of the following methods (fig 4–14):

(1) Place concrete breaching charges (calculated for reinforced concrete) against the bottom of each girder centered over the sides of the girders.

(2) Place concrete breaching charges against the bottom and sides of each girder inside the hollow girder. Access to the inside of the beam must be available.

### 4–25. Truss Superstructures

*a.* Many different types of truss superstructures exist and combinations of different types of trusses are frequently used in large bridges. Trusses may be constructed of any material including timber, but are usually of steel or reinforced concrete. Trusses are used in long spans where beams and girders are not economical. Their spans vary from 150 feet to over 1,000 feet. Some light truss superstructures are encountered in simple spans as short as 60 feet.

*b.* Truss superstructures are destroyed by placing charges to cut the cords or the floor stringers depending upon the degree of destruction desired (fig 4–15). Steel cutting charges, concrete breaching charges, or timber cutting charges are used as appropriate. If the charges are properly placed, it may be possible to effectively destroy the truss span by cutting only the tension cords and thus allowing the weight of the bridge to complete the destruction of the truss. This method, however, should only be used when partial destruction of the truss is an acceptable alternate.

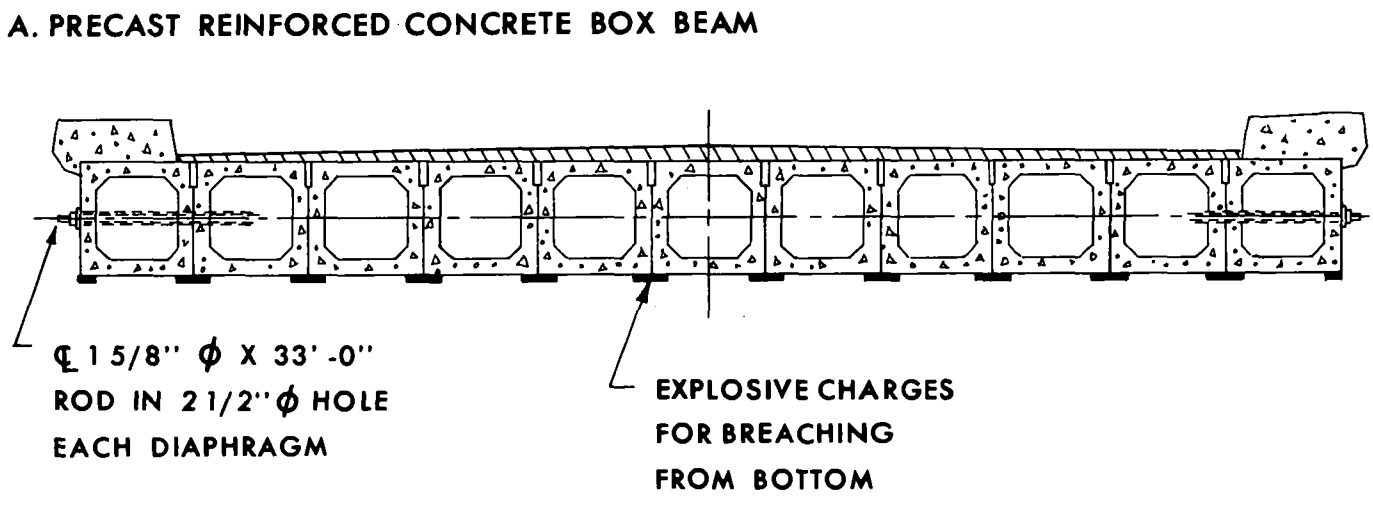



*Figure 4–14. Demolition of concrete box beam superstructures.*

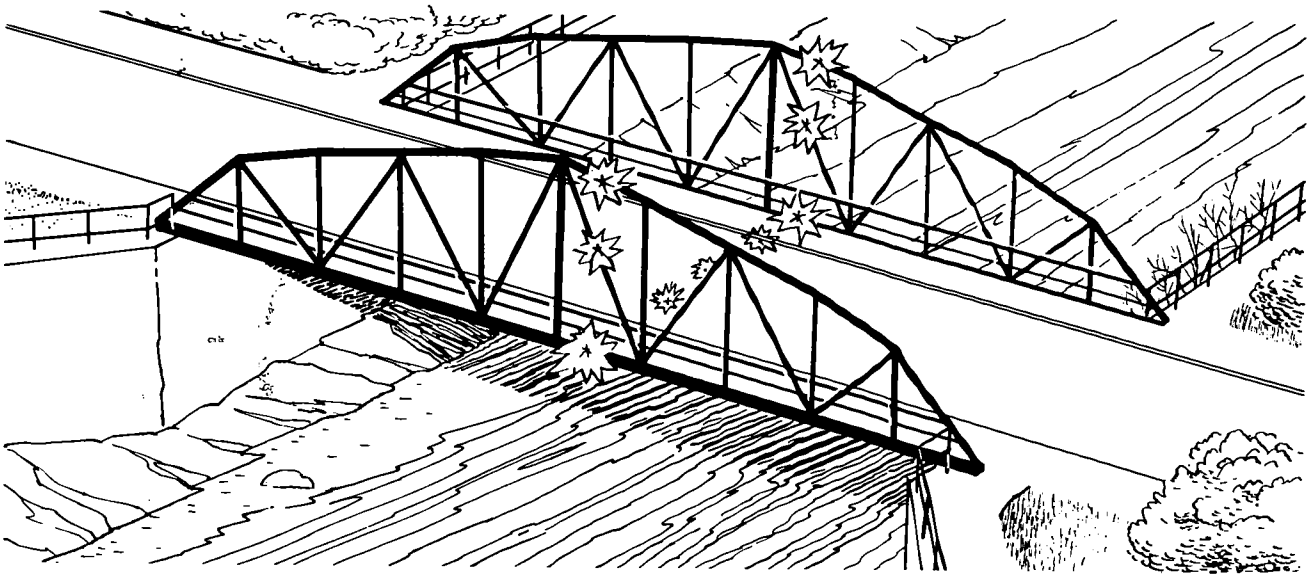


*Figure 4–15. Demolition of truss superstructure.*

## 4–26. Fixed Bridges

Fixed bridges have a great variety of substructures and superstructures. For demolition purposes, fixed bridges are classified according to the method in which the superstructure is supported. By using this method the placement of the charges to destroy the bridge is quickly determined and the correct type of charge or charges may then be selected based on the type of substructure and superstructure.

## 4–27. Simple (Independent) Span Fixed Bridges

*a.* A simple span is defined as any span supported only at each end. The simple span is perhaps the most common type of fixed bridge. It may be as simple as a single span timber stringer bridge, or as complex as a large truss bridge. Simple spans may bridge a small stream, or they may reach from pier to pier to bridge a large river. Simple span bridges may be recognized by the fact that each span is independent of the spans next to it. The stringers or girders of a simple span bridge are of uniform depth and supported only at the ends (fig 4–16). The trusses of a simple span bridge are of uniform height or are higher (built up) in the center of the span and the upper chords of adjacent trusses are not usually connected over a pier (fig 4–17).

*b.* Partial destruction of a simple span bridge is difficult, in that, any demolition normally will destroy one entire span, and may result in more than desired damage to the abutments or piers by the dropping span. To destroy a girder or stringer bridge of this type cut the span at an angle so that the span will fall without excessive damage to the abutments. Partial destruction of a simply supported truss bridge may be accomplished by cutting both trusses at one end, thus letting one end of the bridge fall into the river (fig 4–18). If the distance to the river is not too great, the bridge span should come to rest on an incline, with its uncut end still on its abutment. This will deny the use of both the bridge and the river under it, with the possibility that the greatest portion of the bridge is still intact and can be raised at some future time at considerably less expense than a new bridge.

*c.* Complete destruction of a simple span bridge may be accomplished by several methods. The span may be cut at mid span allowing the bridge to buckle and fall into the river below (fig 4–15). As the bridge falls it will probably damage the abutments also. A second method is more profitable if the bridge rests relatively close to the surface of a swift-flowing stream. This method may be used on truss or girder bridges. Cut both ends of the truss or girder on the upstream side of the bridge close to the abutment allowing it to fall into the water (fig 4–19). The current flowing against the floor of the bridge may complete the destruction by twisting the remaining truss or girder from the abutments and pound the bridge to pieces. Complete destruction of a multispan simple span bridge may be accomplished as outlined above or by destroying each

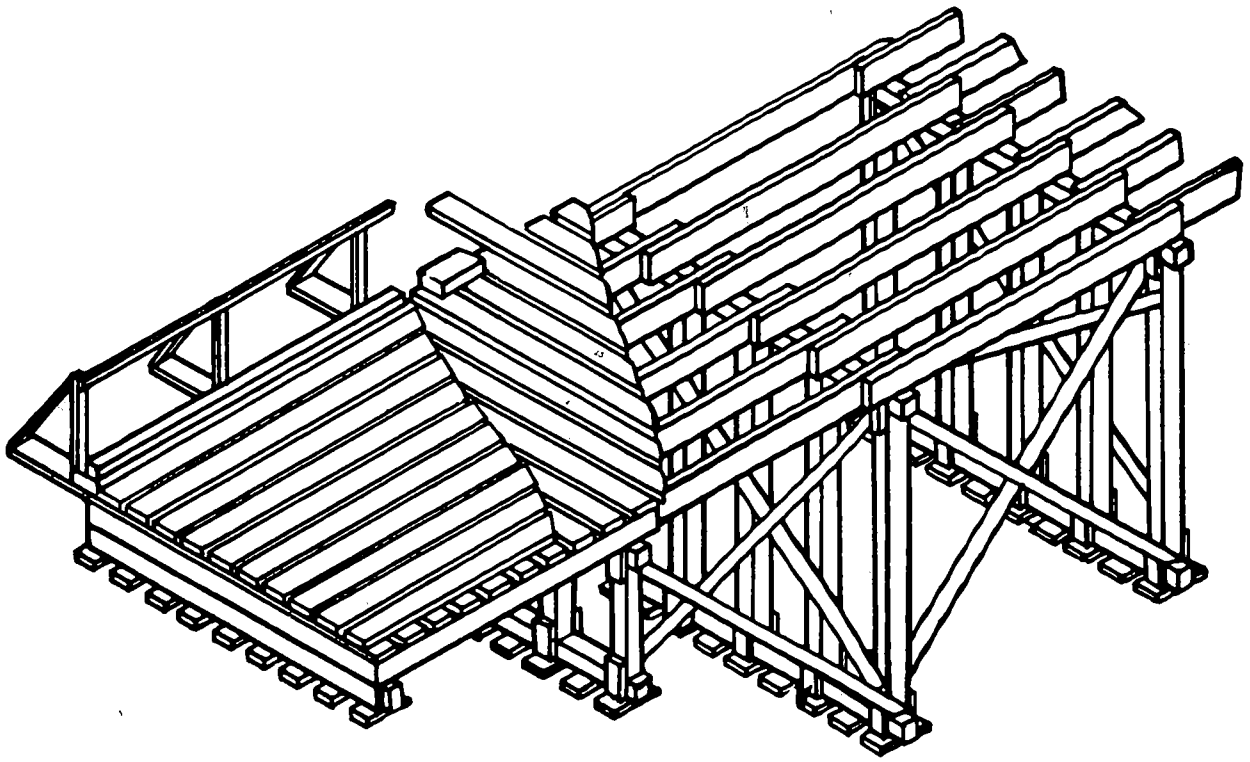


*Figure 4–16. Simple span timber stringer fixed bridge.*

alternate pier. If the terrain is such that the existing bridge site is needed for a new structure, even a temporary one and complete destruction of the bridge is necessary, a multiplespan simple span bridge may be destroyed by cutting each pier on a diagonal breach line alternating the direction of the cut on each pier and cutting the lower members of the span in the center at the same time. This will twist each span so that it may fall on its side between the piers and will destroy each pier so that the maximum amount of debris is left on the site and extensive effort

*Figure 4–17. Simple span truss bridge.*

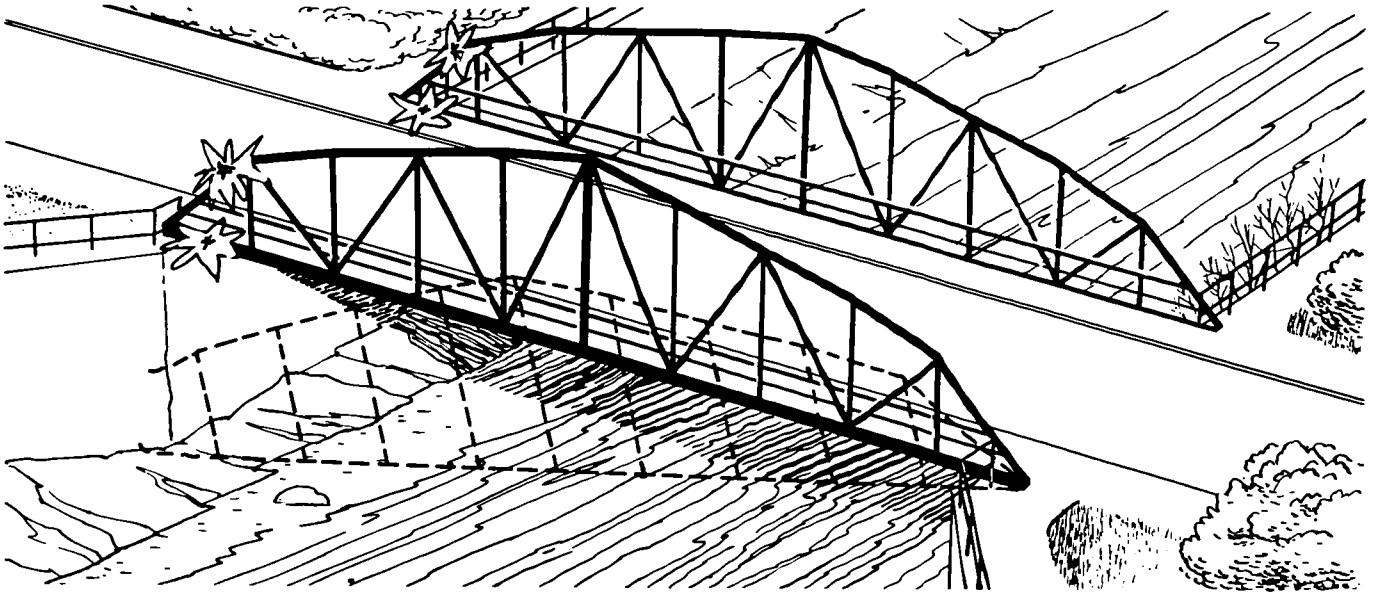


*Figure 4–18. Partial destruction of simple span truss bridge.*

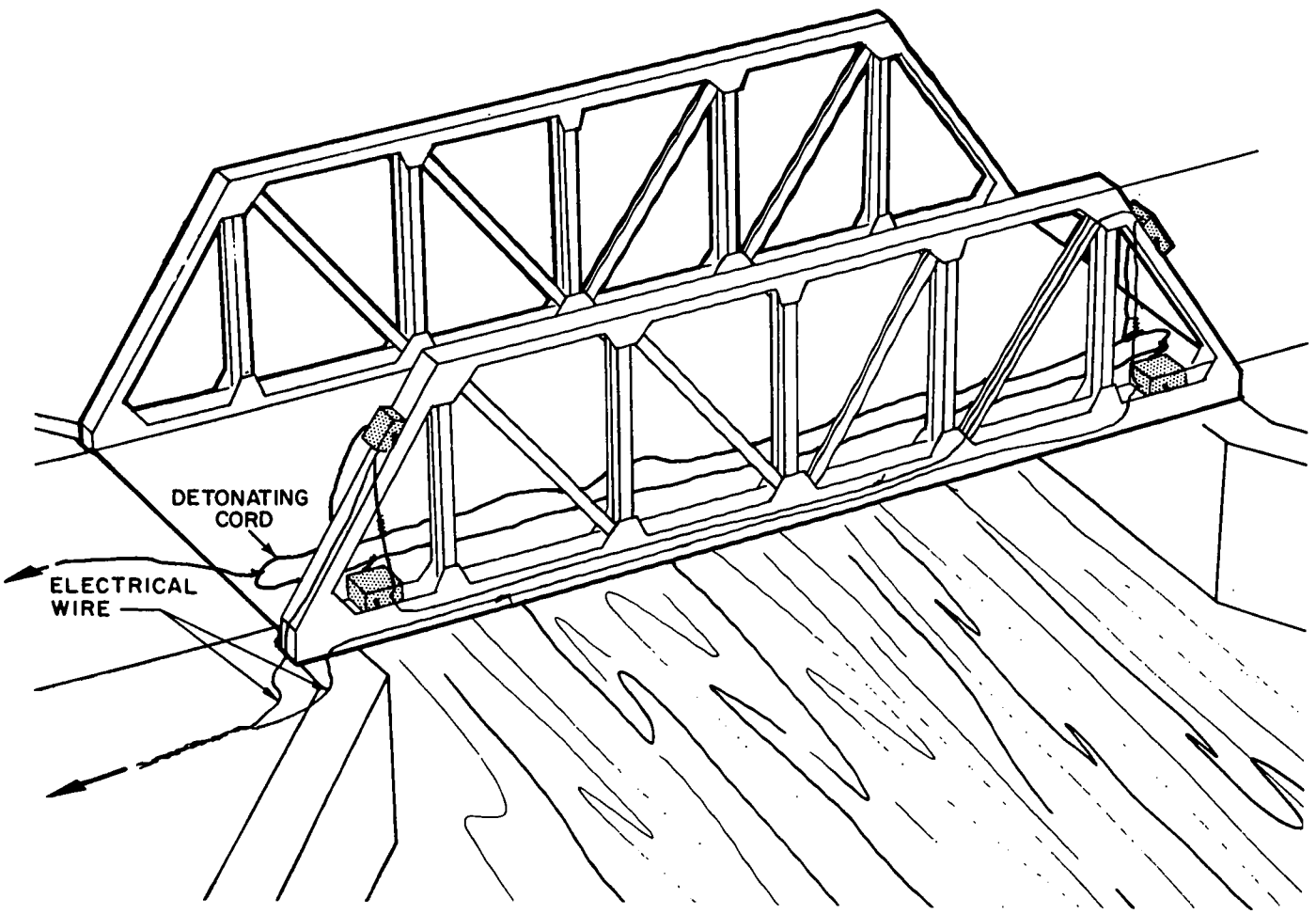



*Figure 4–19. Complete destruction of simple span truss bridge.*

is required before a new bridge may be constructed.

## 4–28. Continuous Span Fixed Bridges

*a.* Continuous spans are spans that are supported at more than two points. The basic type of continuous span bridge would be a simply supported bridge with one pier under the center. Continuous span bridges may be recognized by the fact that the superstructure of the bridge is continuous over the intermediate support. Stringers and girders of a continuous span bridge are normally deepened or haunched at the intermediate support (fig 4–20). The trusses of a continuous span bridge are highest over the supports and are connected at both top and bottom cords.

*b.* The partial demolition of a continuous span bridge may be simply accomplished by cutting the span at the desired distance from one abutment (fig 4–21). This will allow the desired portion of the bridge to drop into the stream, but, because of the strength of the continuous span as it passes over the intermediate pier, the greatest portion of the bridge may remain in place for future use.

*c.* Complete destruction of a continuous span bridge requires that the span be cut on each side of the intermediate piers. The cut should be at unequal distances from the piers so that the portion of the bridge over the pier will be unbalanced and fall. Under ideal conditions, the central portion will overturn or severely damage the supporting pier as it falls (fig 4–22). A useful rule of thumb is to cut the span at three-fourths the total span length from the pier. If time and explosives are available, the piers may also be destroyed by the use of breaching charges.

## 4–29. Cantilever Fixed Bridges

*a.* A cantilever span is defined as a span with one end unsupported. A cantilever bridge is characterized by two arms that extend from opposite banks. Each arm is supported by a pier located approximately one quarter of the distance across the gap (fig 4–23). The portion of the arm between the shore abutment and the pier is the

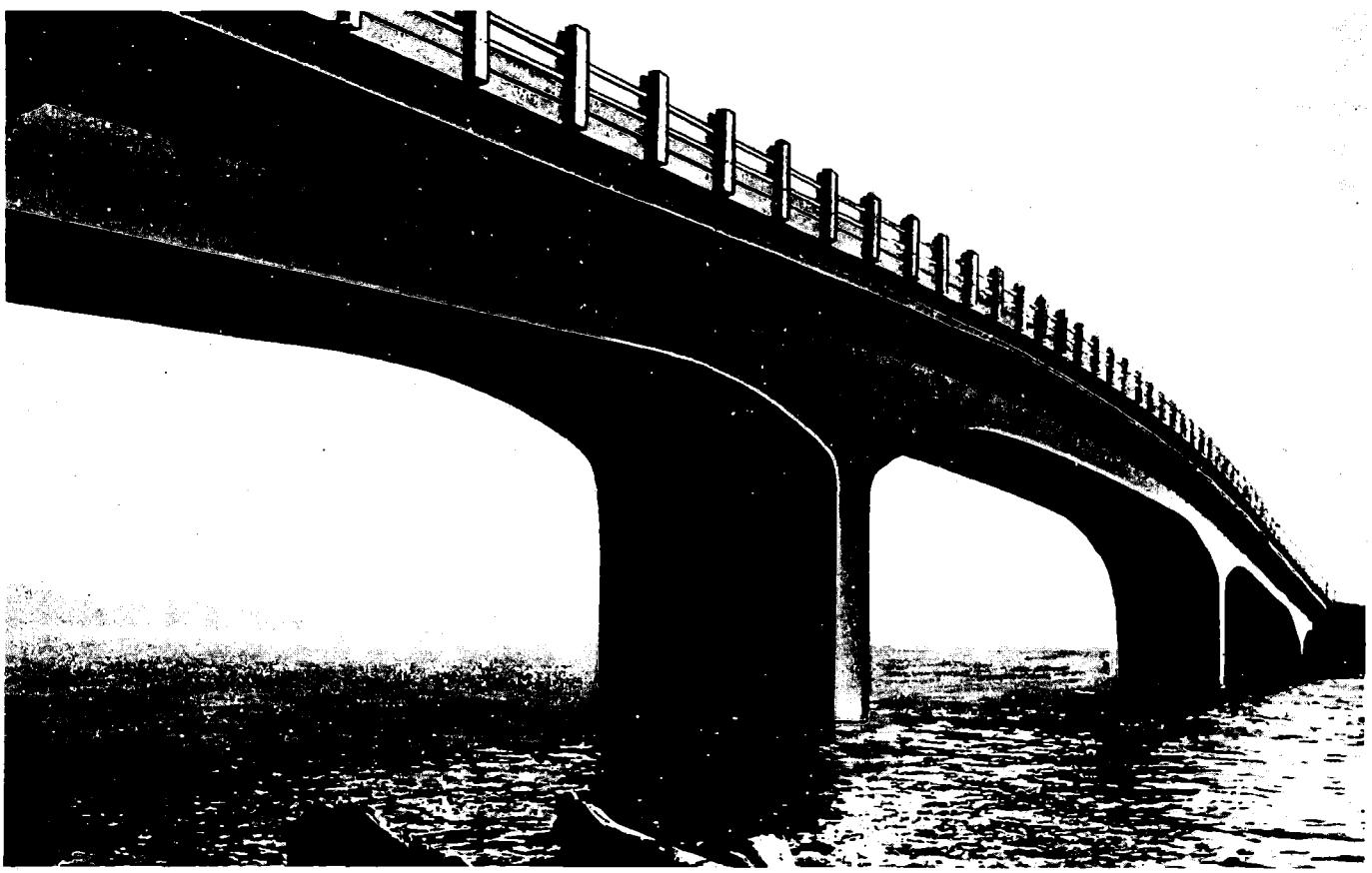


*Figure 4–20. Typical continuous span bridge.*

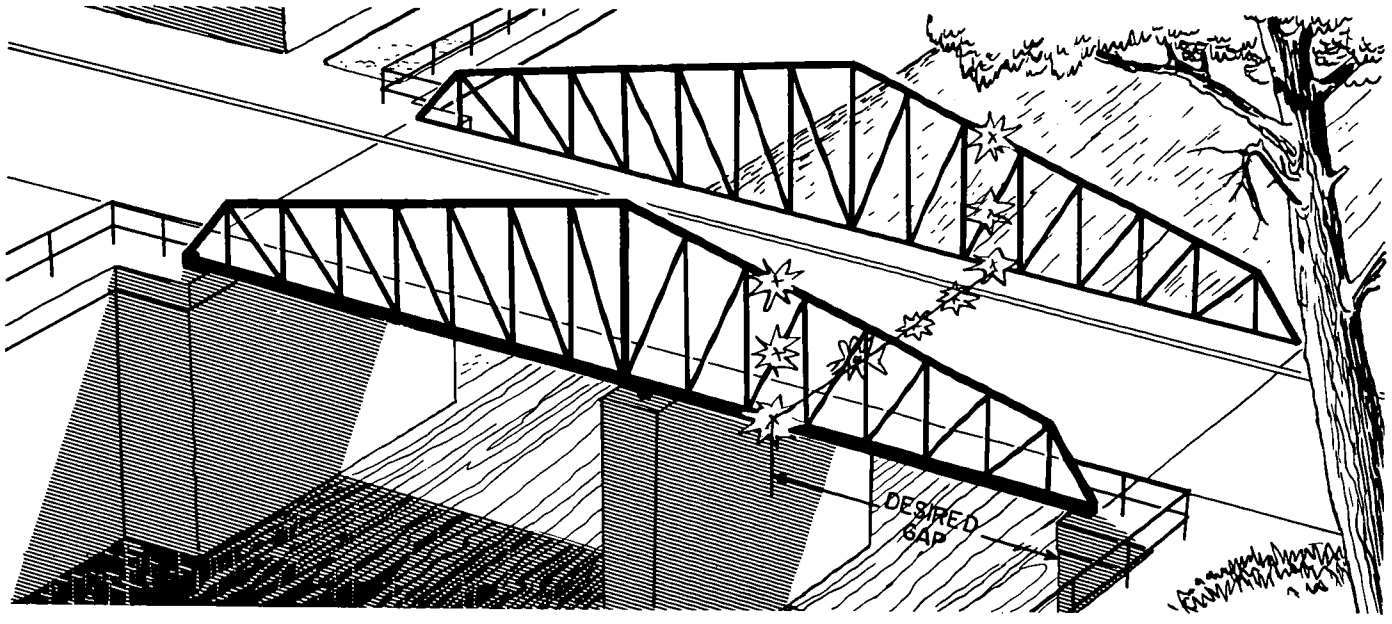



*Figure 4–21. Partial destruction of continuous span.*

anchor arm, while the portion of the arm over the stream is the cantilever arm. The anchor arm may be anchored by a counterweight or solidly fastened to the abutment. Cantilever span bridges may also have a separate span suspended between the ends of the cantilever arms.

*b.* Cantilever bridges are often difficult to distinguish from continuous span bridges because the structural members of a cantilever bridge are also deeper across the intermediate supports. Careful examination of the individual members of the bridge is necessary. The major difference between continuous and cantilever span bridges is the method in which individual mem-

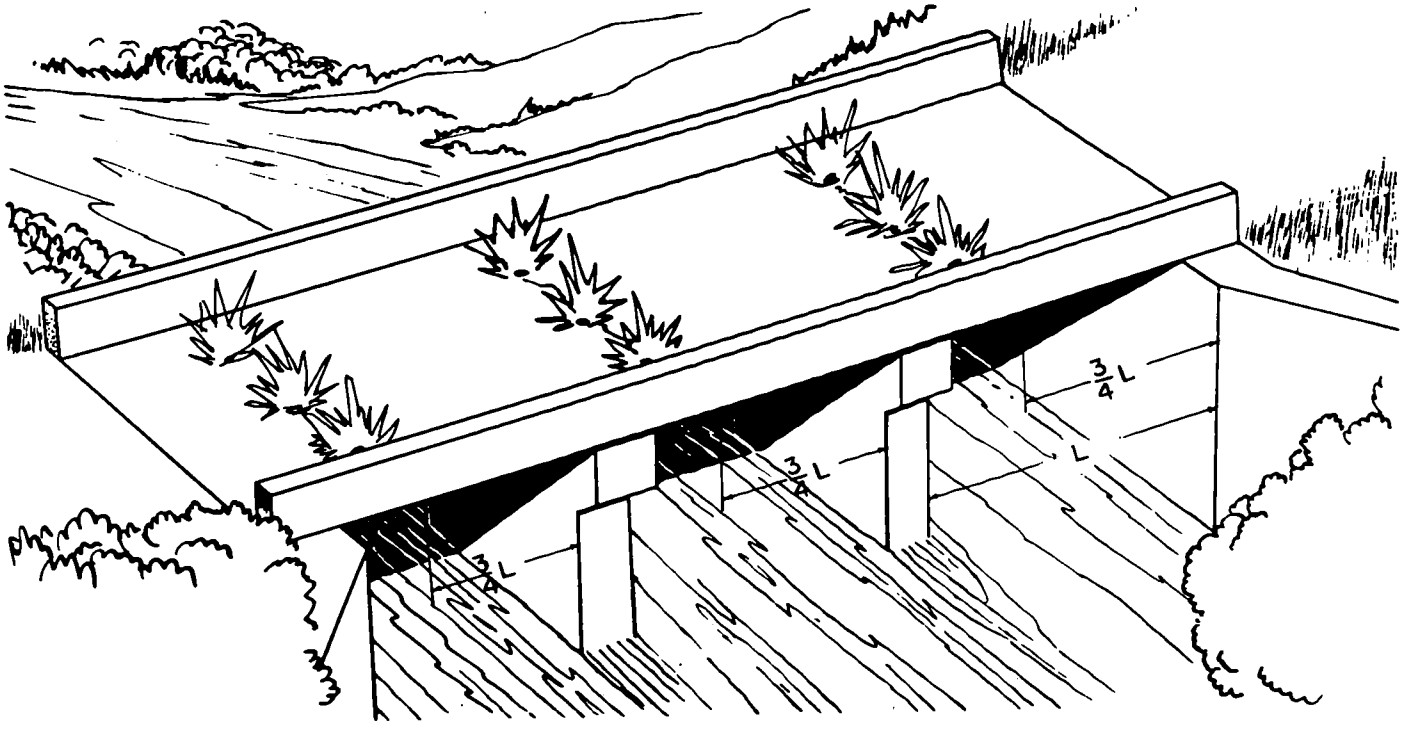



*Figure 4–22. Complete destruction of continuous span concrete slab bridge.*

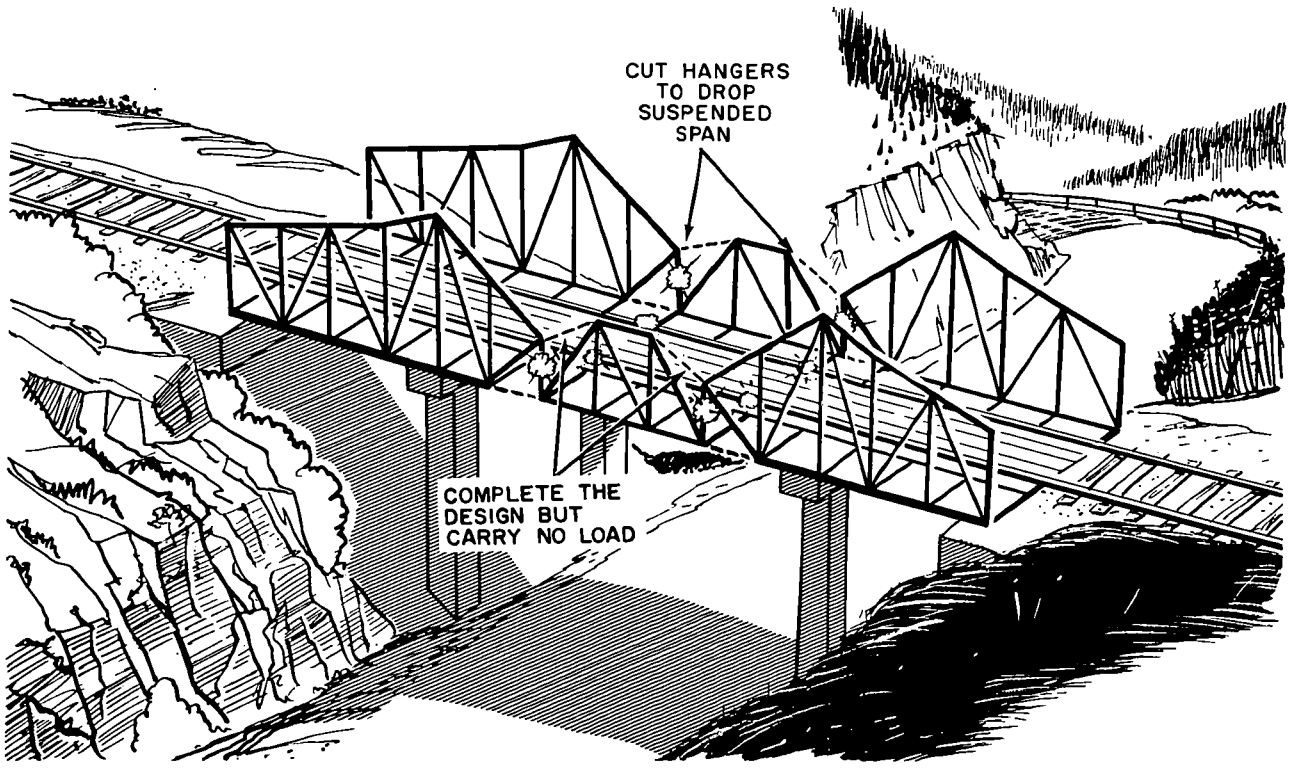



*Figure 4–23. Partial destruction of cantilever truss with suspended span.*

bers are stressed. The upper members of a cantilever bridge are tension members while in all other types of spans the lower members are tension members. Close examination of the abutment support may also indicate a cantilever bridge. The existance of a suspended span also identifies a cantilever bridge.

*c.* Partial destruction of a cantilever bridge with a suspended span may be simply accomplished by dropping the suspended span (fig 4–23). If there is no suspended span, a portion of the cantilever arm can be severed as shown in figure 4–24. Every effort should be made to have all charges detonate simultaneously in either case.

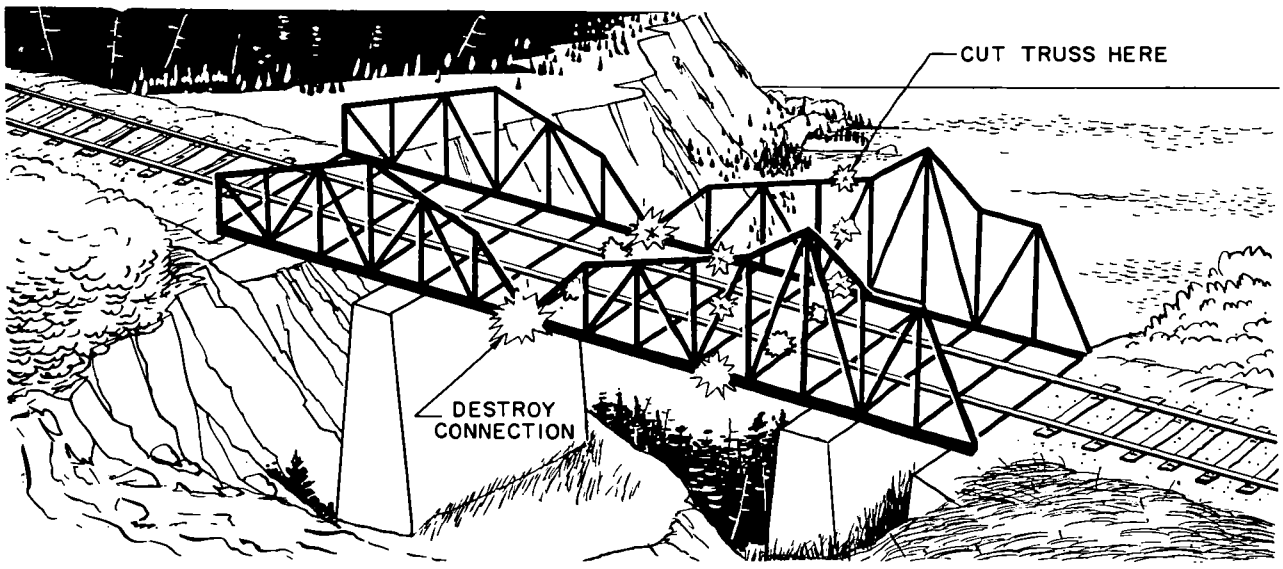



*Figure 4–24. Partial destruction of cantilever truss without suspended span.*

If one end of the severed span were to fall before the other, the cantilever arm may be damaged to a greater extent than necessary or desired.

*d.* Complete destruction of a cantilever bridge may be accomplished by treating the cantilever arms as a continuous span and cutting them at an unequal distance from the supporting pier to cause overturning of the portion of the bridge supported by the pier (fig 4–25).

## 4–30. Arch Span Fixed Bridges

*a. Components.* A few of the components of bridge arches are described below and illustrated in figure 4–26.

(1) *Span.* The horizontal distance from one support of an arch to the other measured at the spring line.

(2) *Spring lines.* The points of junction between the arch and the supports.

(3) *Rise.* The vertical distance measured from the horizontal line connecting the supports at the base of the arch to the highest point on the arch.

(4) *Crown.* The highest point on the arch.

(5) *Abutments.* The supports of the arch.

(6) *Haunches.* Those portions of the arch that lie between the crown and the spring lines.

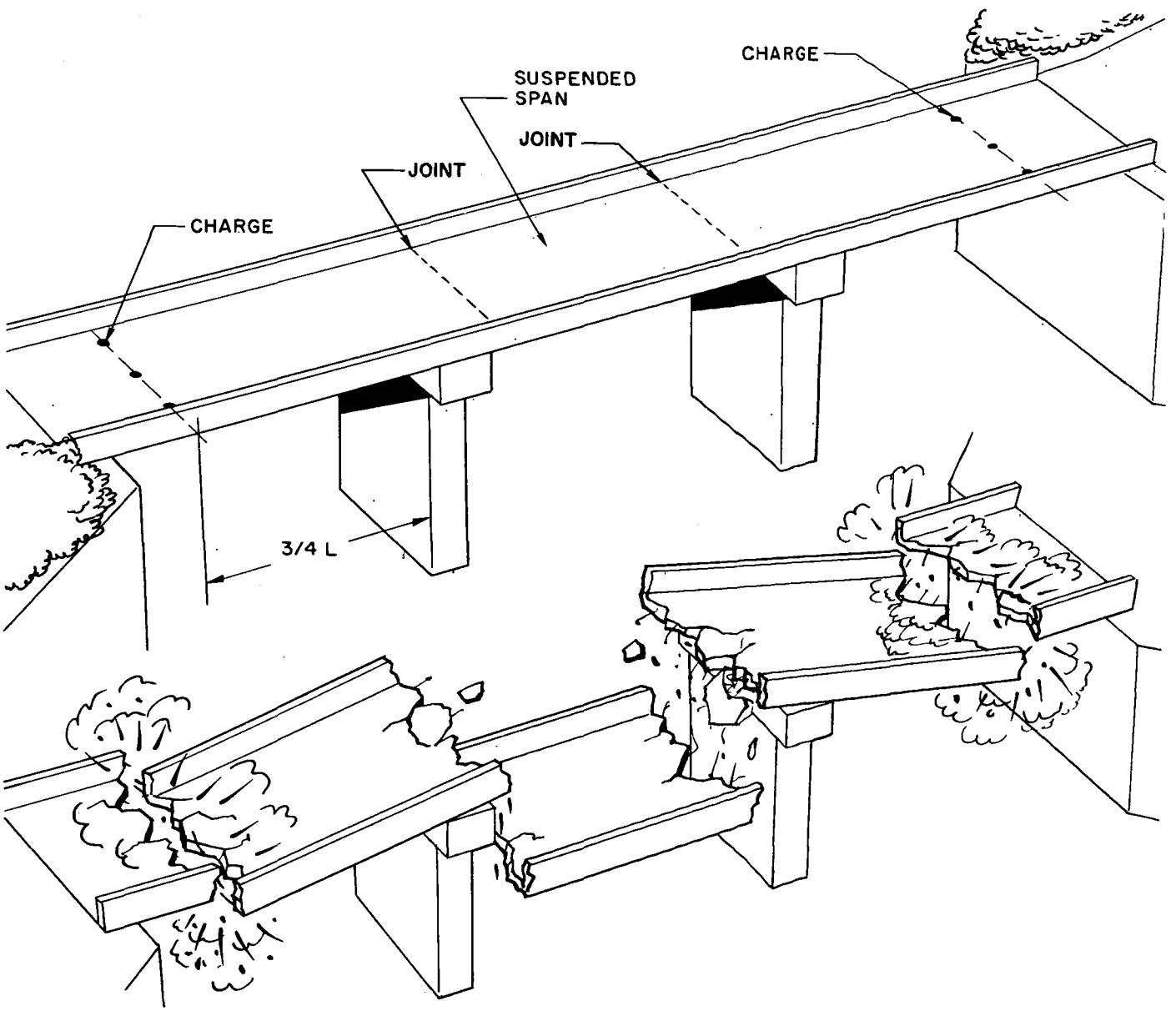



*Figure 4–25. Complete destruction of concrete slab cantilever bridge with suspended span.*

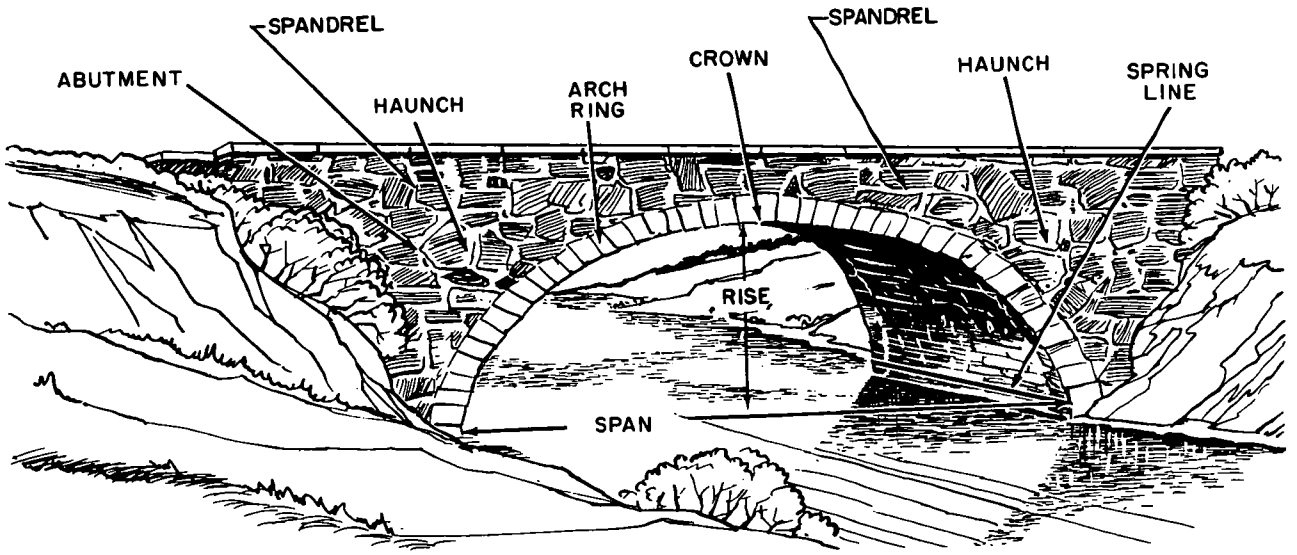



*Figure 4-26. Arch components.*

(7) *Spandrels.* The triangular-shaped areas between the crown and abutment and above the haunches.

*b. Filled Spandrel Arch.* A filled spandrel arch consists of a barrel arch (comparatively short span) supporting an earth or rubble fill between the retaining walls. The arch is the most vulnerable at its crown, where it is the thinnest and the earth fill is usually only a foot or two thick. Filled spandrel arches are constructed of masonry (stone or brick), reinforced concrete, or a combination of these materials. They may be destroy-

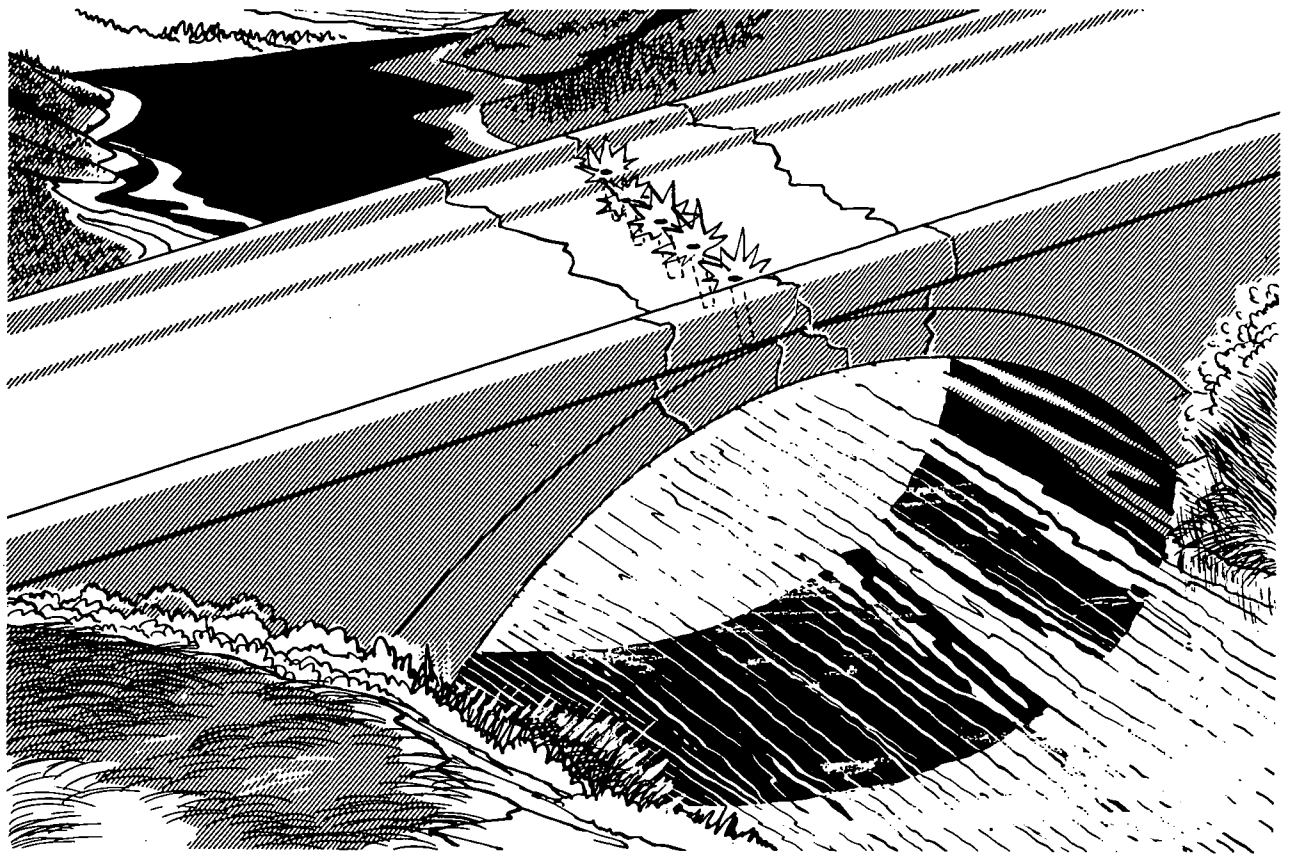


*Figure 4-27. Breaching by crown charges on filled spandrel arch bridge.*

ed by breaching charges placed at either the crown or haunch.

*c. Demolition by Crown Charges.* Crown charges are more easily and quickly placed than haunch charges; but their effectiveness is substantially less, particularly on an arch with a rise that is large in comparison with the span. Crown charges are more effective on the flatter arches because the flatter shape permits a longer portion of the arch to drop out of the bridge. Breaching charges are placed as shown in figure 4–27.

*d. Demolition by Haunch Charges.* Breaching charges may be placed at the haunches (just ahead of the abutment) as shown in figure 4–28 and the traffic maintained until they are fired. If the bridges have demolition vaults or chambers built into the haunches, the charges should be placed there. The presence of demolition vaults is usually revealed by the ventilating brick or steel plate laid in the side wall of the arch. Charges placed in the haunch on the left side will drop out that portion of the arch between lines C and D as shown in figure 4–28. Charges in both haunches will drop out that portion of the arch between lines C and E. The breaching charges must be placed on the arch ring either in holes on the top or supported on the under side.

## 4–31. Open Spandrel Arch Bridges

An open spandrel arch consists of a pair of arch ribs that support columns or bents which in turn support the roadway. The number of arch ribs may vary, and on rare occasions the spandrel bents may be placed on a full barrel arch similar to that which supports the filler material of the filled spandrel arch. The open spandrel arch bridge (fig 4–29) may be constructed of reinforced concrete, steel, timber, or any combination of those materials.

*a. Demolition of Concrete Open Spandrel Arch.* The ribs of a concrete open spandrel arch bridge (fig 4–29) are about 5 feet wide. The thickness of the arch rib at the crown varies from about 1 foot for spans of 50 to 60 feet in length to 3 feet for spans of 200 feet or more. The arch thickness at the spring line is ordinarily about twice the thickness at the crown. In long spans, the ribs may be hollow. The floor slab is usually close to the crown, permitting packing of charges against the rib at this point. Since for structural reasons,

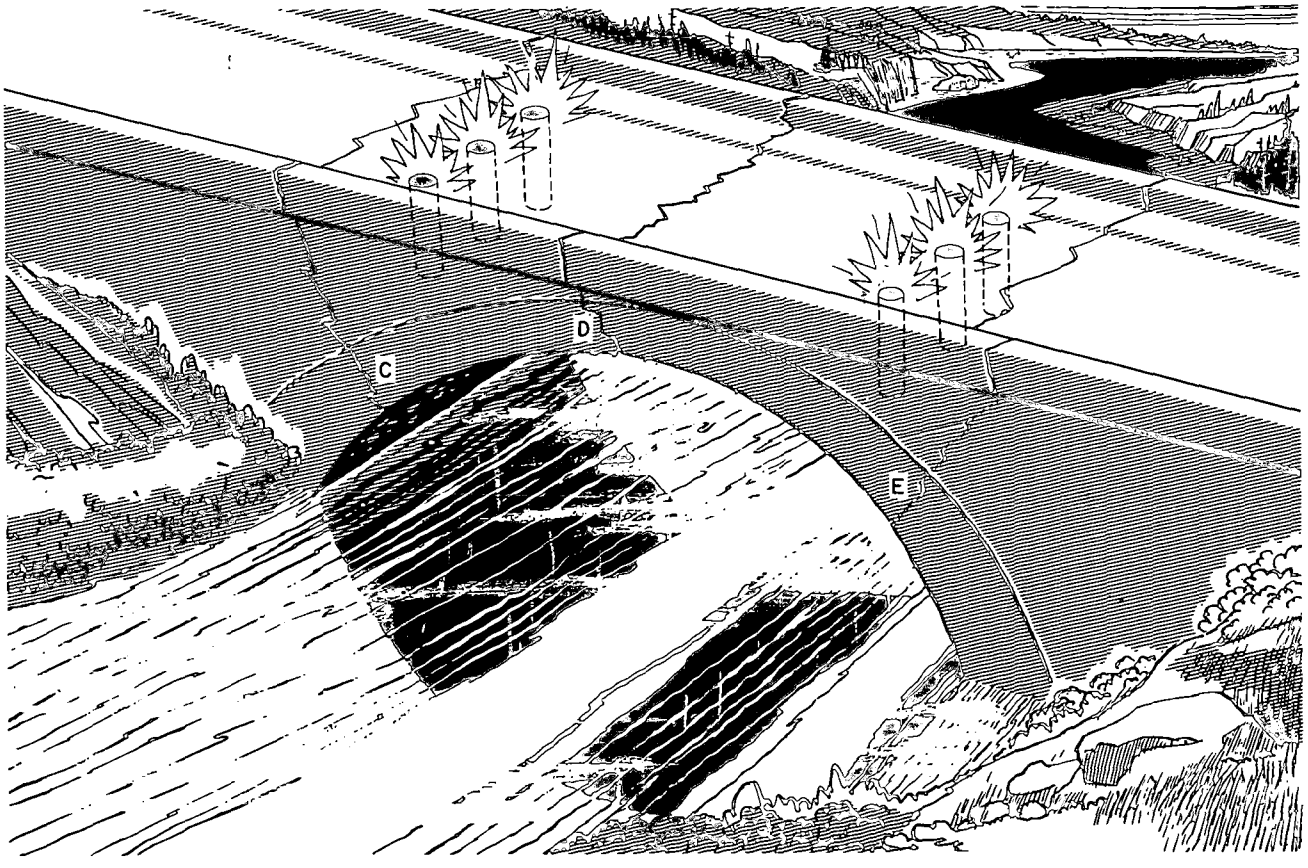



*Figure 4–28. Breaching by haunch charges on filled spandrel arch bridge.*

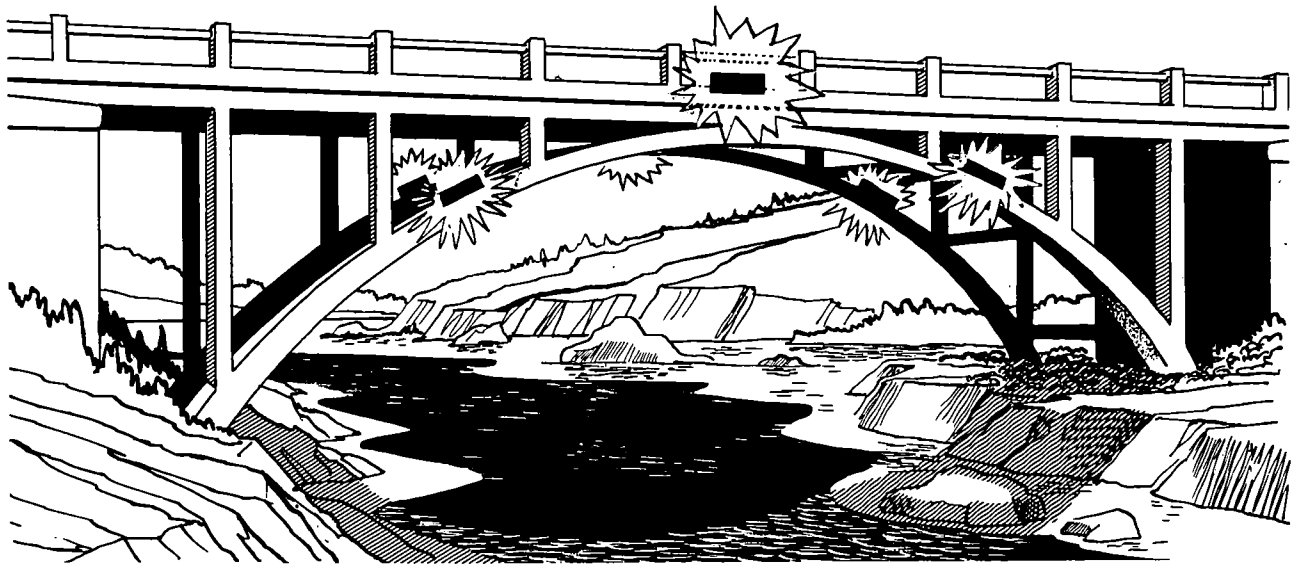


*Figure 4–29. Demolition of reinforced concrete open spandrel arch bridge.*

the haunch over the abutment is most likely to be heavy, effective destruction of the arch itself by means of light crown charges may leave a substantial pier at roadway level in an undamaged condition. This type of structure is usually built in one massive unit rather than in lighter separate component parts and is very tough. Also, cutting the span at each end may drop the whole span only a relatively short distance. This may make the damaged bridge an excellent support for building a new temporary bridge. Therefore to prevent utilization of such a span, one charge is placed at the haunch and another at the crown. The uncut half-span will then also fall if the total span exceeds 50 or 60 feet. The charge at the haunch is computed for placement at either the ring or the pillar over the support, whichever has the greater radius. For short single arch spans, destroy the entire span with breaching charges laid behind the abutments or behind the haunches.

*b. Demolition of Steel Arch Span.* Steel arches are of four general types: continuous arches ((1) fig 4–30), one-hinged arches (2), two-hinged arches (3), and three-hinged arches (4). One-hinged arches are hinged in the middle; two-hinged arches, at both ends; and three-hinged arches, at both ends and in the middle. Continuous arches and one-hinged arches are destroyed by placing charges at both ends of the span just far enough from the abutment to allow the arch to fall. Two-hinged and three-hinged arches need only one charge apiece for destruction. This should be placed at the center of the span.

## 4–32. Suspension Span Bridges

The suspension span bridge is usually a major bridge distinguished by two characteristics: The roadway is carried by a flexible member, usually a wire cable, and the spans are long (fig 4–31).

*a. Components.*

(1) *Cables.* Cables of suspension bridges are usually two steel multiwire members that pass over the tops of towers to anchorages on each bank. The cables are the load-carrying members. (The "Golden Gate" bridge has 127,000 miles of cable wire.)

(2) *Towers.* Towers of a suspension bridge support the cables or load-carrying members. They may be made of steel, concrete, masonry, or a combination of these materials.

(3) *Trusses or girders.* The trusses or girders of a suspension bridge do not support the load directly. They provide stiffening only.

(4) *Anchorage.* The usual anchorage is merely the setting of the splayed end of the cable in a rock or a concrete mass. This may be large—sometimes as much as 10,000 cubic feet in size.

*b. Destruction.*

(1) *Major structures.* The towers and anchorages of a major suspension bridge are usually too massive to be destroyed, and the cables are too thick for positive cutting with explosives. The most economical method of destruction is either by dropping the span leading onto the bridge or dropping a section of the roadway by cutting the

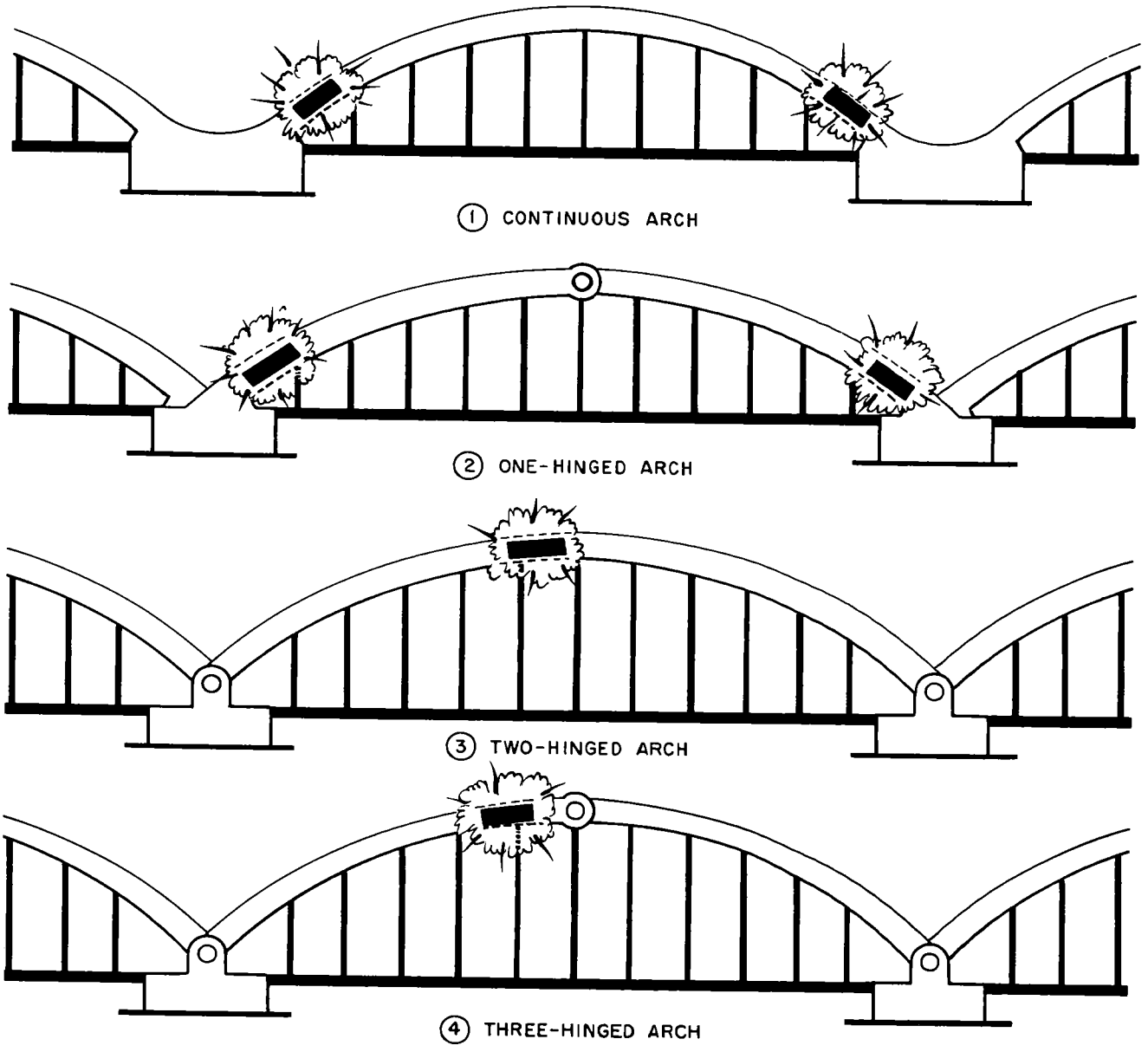



*Figure 4–30. Demolition of steel arch bridges.*

suspenders of the main or load-bearing cables. The length of this section should be determined by an analysis of what capabilities the enemy has for repair in the time he is expected to retain the site, particularly the erection of a prefabricated bridge. It may also be feasible where there are reinforced concrete towers to breach off the concrete and cut the steel.

(2) *Minor structures.* The two vulnerable points of a minor suspension bridge are the tower and the cables.

(3) *Towers.* Charges may be placed on the towers slightly above the level of the roadway. A section should be cut out of each part of each tower. A charge is placed on each post to force the ends of the cutout section to move in opposite directions twisting the tower. This will prevent the ends of a single cut from remaining in contact. Demolition chambers, provided in some of the newer bridges, make blasting easier, quicker, and more effective.

(4) *Cables.* Charges should be placed on the cables as close as possible to firm support such as at the top of the tower or at an anchorage. Extreme care should be taken to extend the charges not more than one-half the distance around the circumference of the cable. These charges are bulky, exposed, and difficult to place; and the

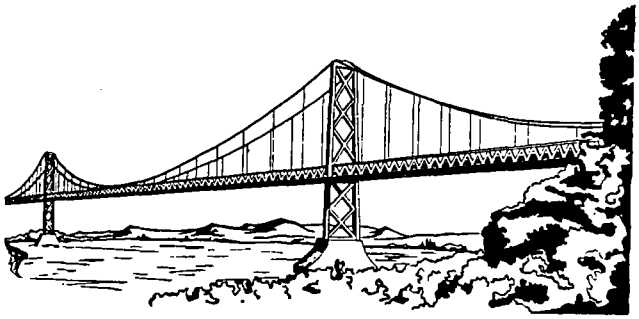


*Figure 4–31. Suspension span bridge.*

cables are difficult to cut because of the air space between the individual wires. Shaped charges, however, with their directed force effect, may be used to advantage.

## 4–33. Movable Bridges

A movable bridge is a bridge having one or more spans capable of being changed in position to open a clear passage, or to give an increased clear height for traffic in navigable channels. The three most basic types of movable bridges are discussed below.

## 4–34. Swing Span Bridges

*a.* The swing span is probably the most common type of movable bridge. Basically, a swing span is a continuous span which can be rotated on its central pier to provide clear passage for waterborne traffic. The arms of a swing span bridge may or may not be of equal length. If the arms are of unequal length, weights are added to balance them. The weight of the span is carried by rollers which run on a circular track atop the center pier with the pivot serving as a center only. The swing span of a bridge is independent from any other spans of the bridge and may be recognized by the wide central pier under the swing span which is much wider than under a continuous span to accommodate the necessary rollers and turning mechanism required to rotate the span (fig 4–32).

*b.* Because the swing span bridge is the continuous type partial and complete destruction may be accomplished as a continuous span bridge as discussed in paragraph 4–28. The swing span may also be swung open and the rotating mechanism damaged, if this will answer the partial demolition requirement.

## 4–35. Bascule Bridge

*a.* The bascule bridge is a movable bridge and is more familiarly referred to as a drawbridge. Usually there are two leaves which fold upwards when the bridge is opened (fig 4–33); but there may be only a single leaf (fig 4–34). Bascule bridges appear in three general forms. The first two forms are similar in that the movable arms are balanced by a counterweight. The type illustrated in figure 4–33 is the most modern design and is characterized by having the counterweight below the road level. The older type may have the counterweight above the road level. The third type (fig 4–35) has no counterweight but is lifted by a cable or rope. This is a very early form of bascule and is widely used in underdeveloped countries throughout the world. This type is normally made of timber to reduce the weight of the movable span.

*b.* Because the bascule bridge usually consists of one or two cantilever arms, these arms may be demolished as discussed in paragraph 4–29 to effect either partial or complete destruction. In addition the operating mechanism may be damaged to jam the bridge in the opened position.

## 4–36. Vertical Lift Bridge

*a.* The movable span in this type of bridge is a simple span which can be raised vertically out of the path of traffic. The simple span is sup-

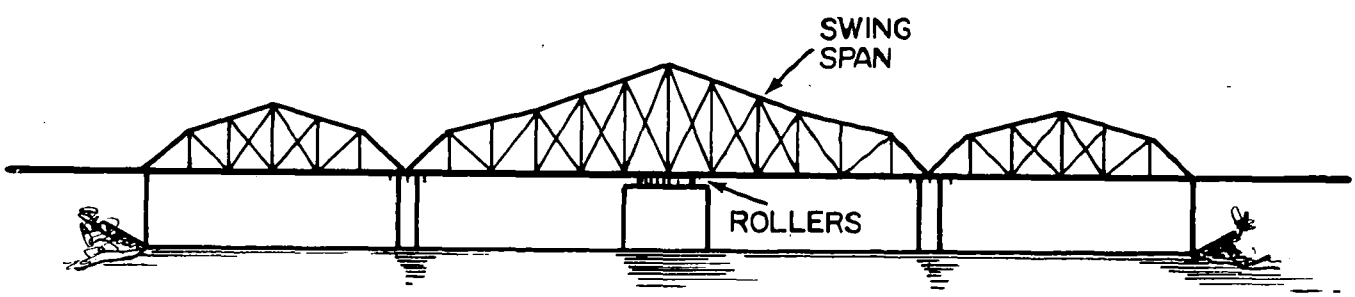



*Figure 4–32. Swing span truss bridge.*

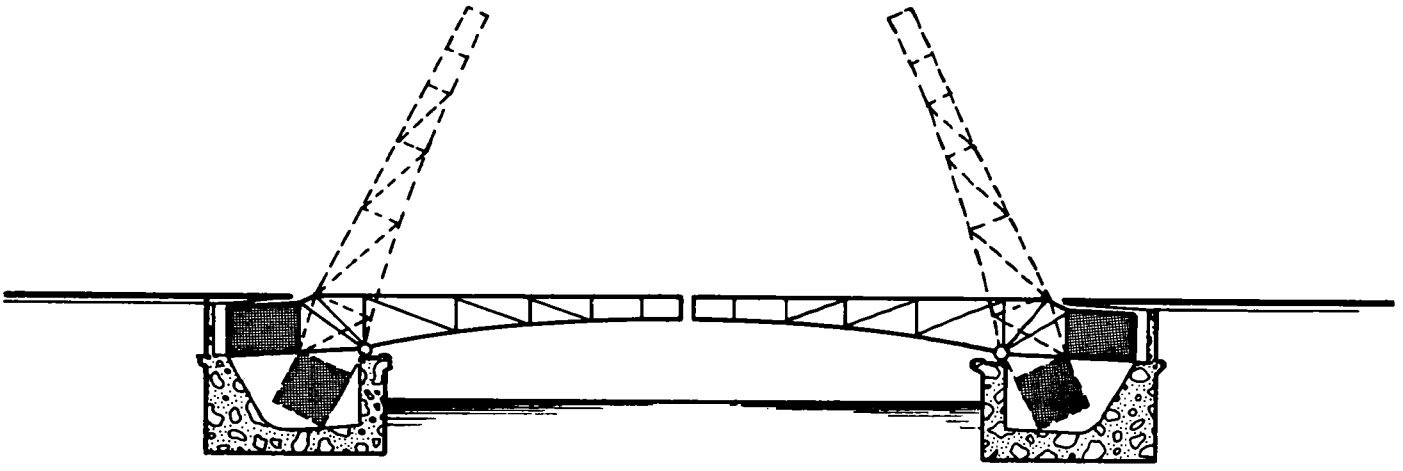


*Figure 4–33. Double-leaf bascule bridge.*

ported on cables which pass over rollers and are connected to large movable counterweights. The height of the towers will govern the height to which the span may be raised (fig 4–35).

*b.* The movable span of the vertical lift bridge may be attacked as any simple span (para 4–27) or the cables supporting counterweights can be cut. Cutting these cables will prevent raising the bridge. Complete or nearly complete destruction can be accomplished by cutting one end of the movable span free when the bridge is raised. The movable span will either wedge between the supporting towers, or will fall free and severely damage the other tower.

## 4–37. Floating Bridges

Floating bridges consist of a continuous roadway of metal or wood supported by floats or pontons (fig 4–36).

*a. Pneumatic Floats.* Pneumatic floats consist of rubberized fabric made into airtight compartments and inflated with air.

(1) *Hasty method of destruction.* The anchor cables and bridle lines may be cut with axes and the steel cable, by explosives.

(2) *Deliberate method of destruction.* The floats may be punctured by small arms or machinegun fire. This requires a considerable volume of fire because of the large number of water-

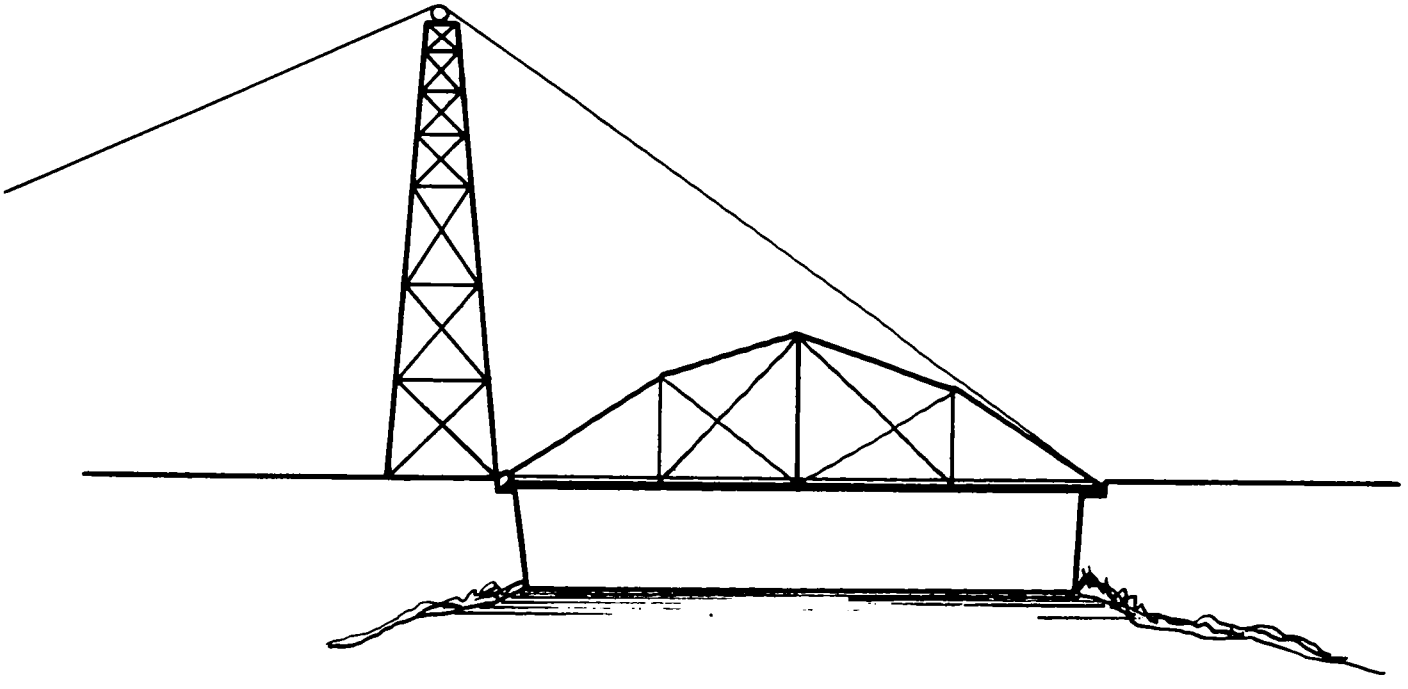


*Figure 4–34. Single-leaf bascule bridge.*

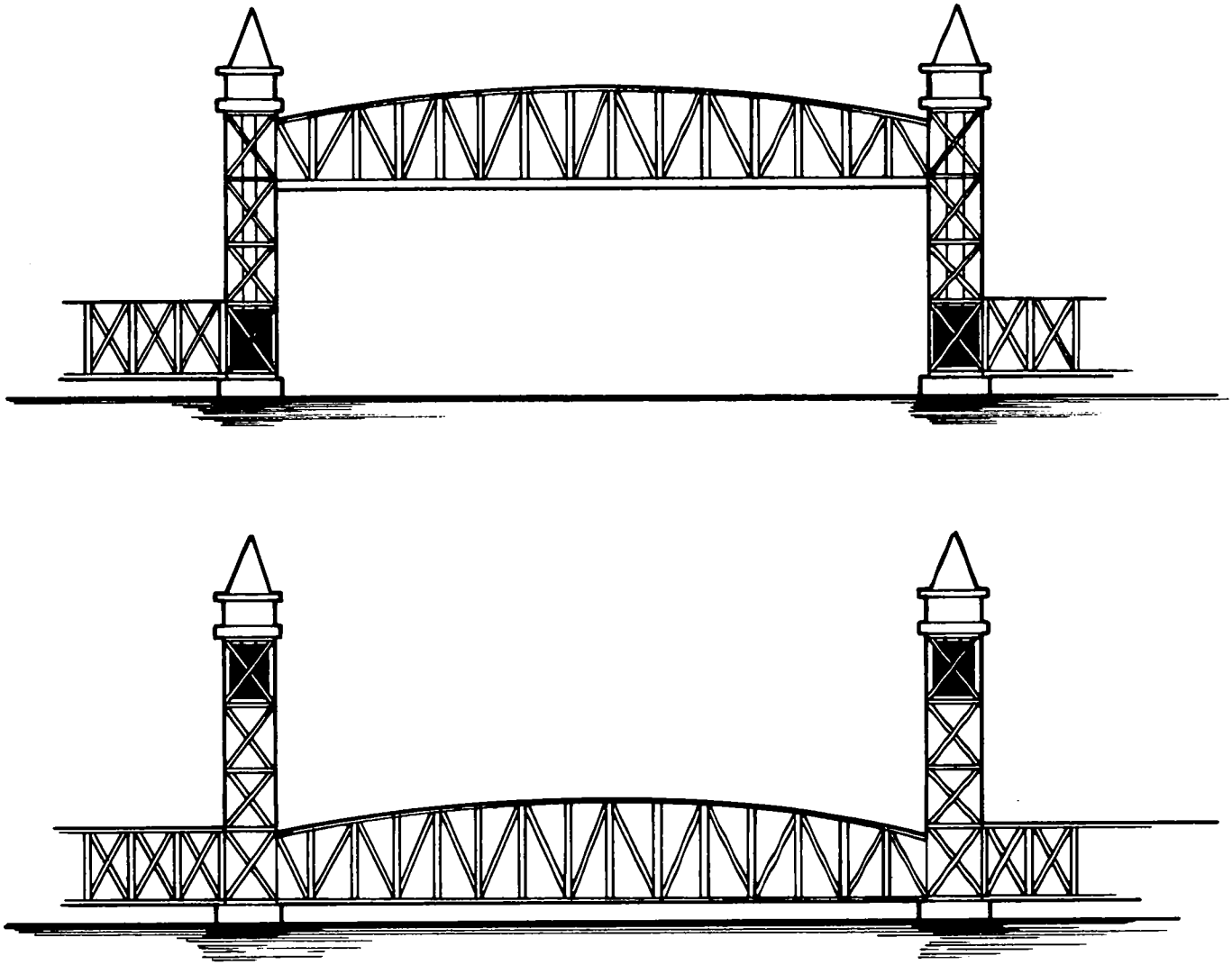


*Figure 4–35. Vertical lift bridge.*

tight compartments in each float. Detonating cord stretched snugly across the surface of inflated ponton compartments will make a clean cut through the material. One strand will suffice to cut most fabrics; two may be required for heavier material. Also one turn of detonating cord around an inflation valve cuts it off at the neck or does other damage. Lines placed around valves should not be main lines but branch lines run off from the main line, as the blast wave may fail to continue past the sharp turn.

*b. Rigid Pontons.* Rigid pontons are made of various materials such as wood, plastic, or metal. Most of these are open but occasionally they are decked over.

(1) *Hasty method of destruction.* A ½-pound charge of explosive is placed on the upstream end of the bottom of each ponton and all are detonated simultaneously. If the current is rapid, another method is to cut the anchor cables so that the bridge will be carried downstream.

(2) *Deliberate method of destruction.* The bridge is severed into rafts and half-pound charges of explosives are placed at each end of each ponton and detonated simultaneously.

*c. Treadways.* Charges to destroy the treadway of any metal treadway type of floating bridge may be calculated by means of the steel-cutting formula. The placement and amount of the charges to be used depends on the type of bridge to be destroyed. In general, if charges are set to sever the roadway completely at every other joint in the treadway, the bridge will be damaged beyond use.

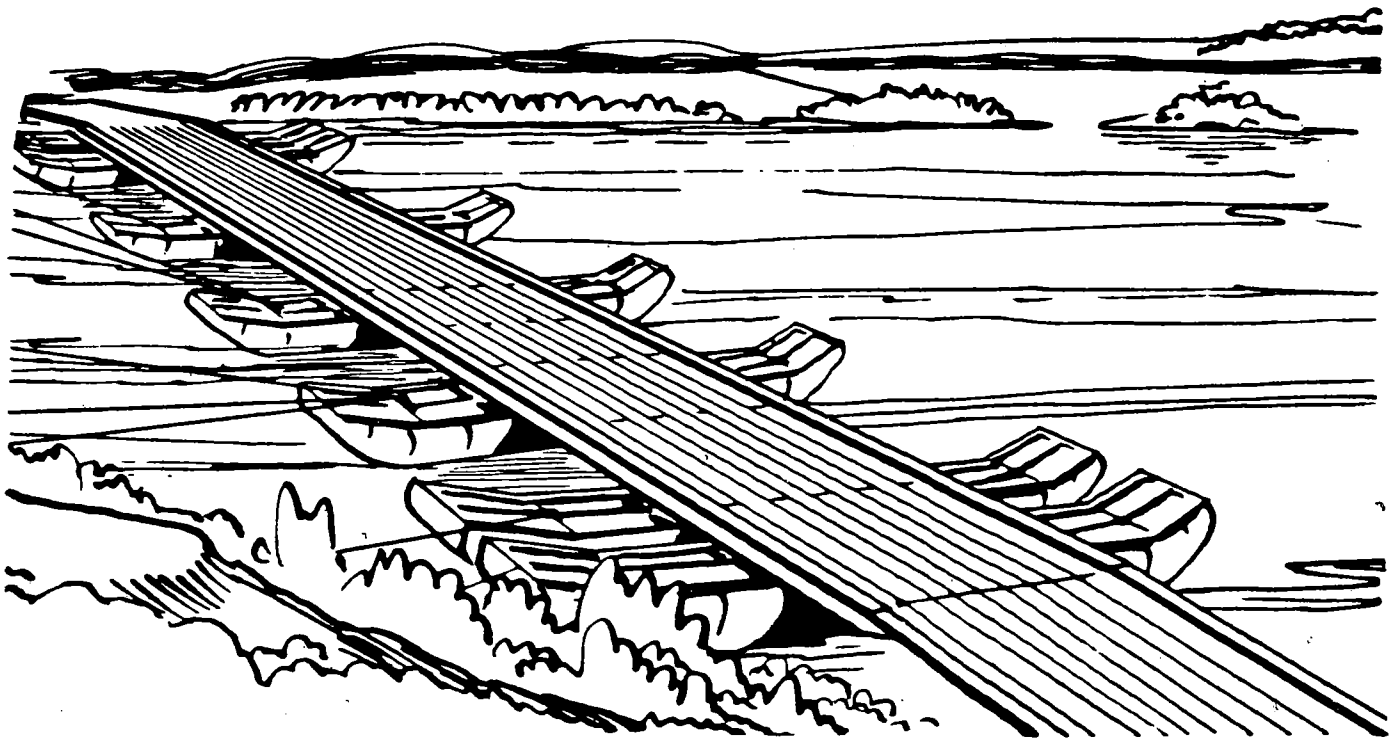


*Figure 4–36. Floating bridge.*

## 4–38. Bailey Bridges

A 1-pound charge placed between the channels of the upper and lower chords will destroy the panels. A ½-pound charge will cut the diagonals and a 1-pound charge, the sway bracing (fig 4–37).

*a. Bridge in Place.*

(1) The bridge is severed into parts by cutting panels on each side, including the sway braces. The line of cut is staggered through the panels; otherwise the top chords may jam and prevent the bridge from dropping. In double-story or triple-story bridges, the charges are increased on the chords at the story junction line.

(2) For further destruction, charges are placed on the transoms and the stringers.

*b. Bridges in Storage or Stockpile.* Destruction of bridges in storage must be such that the enemy cannot use any of them as a unit or any parts for normal or improvised construction. This requires that one essential component, not easily replaced or improvised, be destroyed so that the bridges at a particular stockpile cannot be used. In this way it will also be impossible for the enemy to obtain replacements for other sectors. The component that fulfills all of these conditions is the panel. To make the panel useless, the female lug in the lower tension cord is removed or distorted. All panels should be destroyed before other components are destroyed.

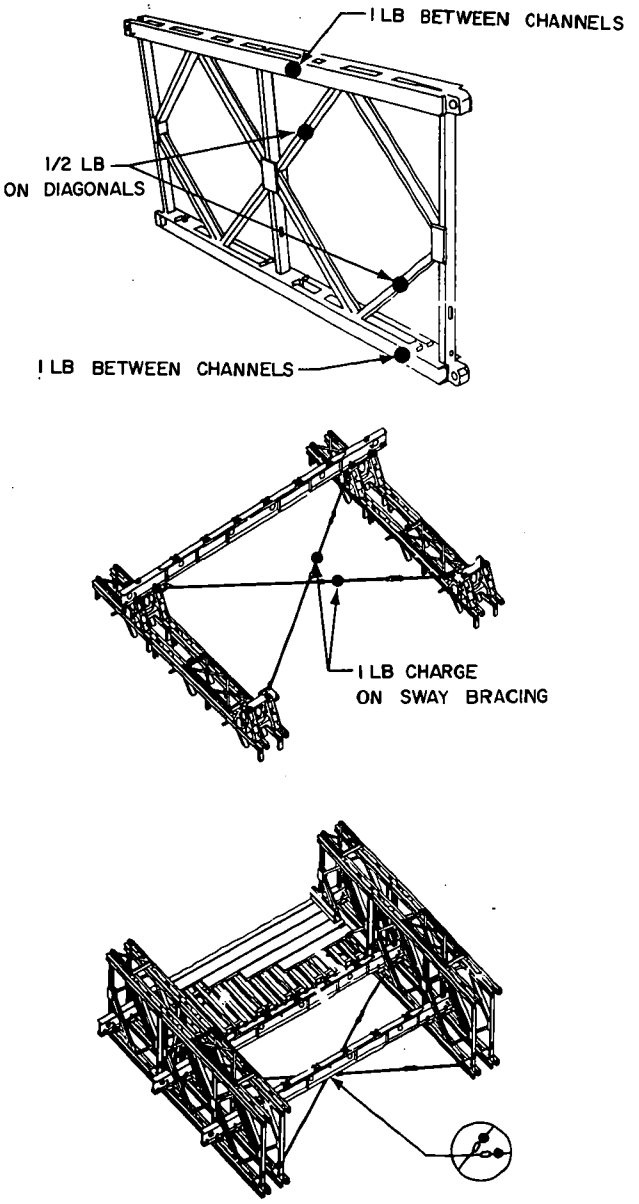



*Figure 4–37. Demolition of Bailey bridge.*

## Section IV. DAMAGING TRANSPORTATION LINES

### 4–39. Highways

Disruption of enemy transportation lines is an important demolition objective. The extent of demolition, however, depends upon the analysis of the system and the mission. By the destruction of the road net, the attacking forces are halted or delayed, the movement of supplies is prevented, and frequently new construction is required before the enemy can advance. This may be accomplished by the demolition of bridges and tunnels, by blowing road craters, by placing wrecked items of equipment and debris in cuts and defiles, and by the construction of abatis and roadblocks.

### 4–40. Railroads

*a. Tracks.*

(1) If possible, the destruction of railroads with explosives should be done at vulnerable points. These are curves, switches, frogs, and crossovers, which may be destroyed with a small amount of explosive. This is called the "spot"

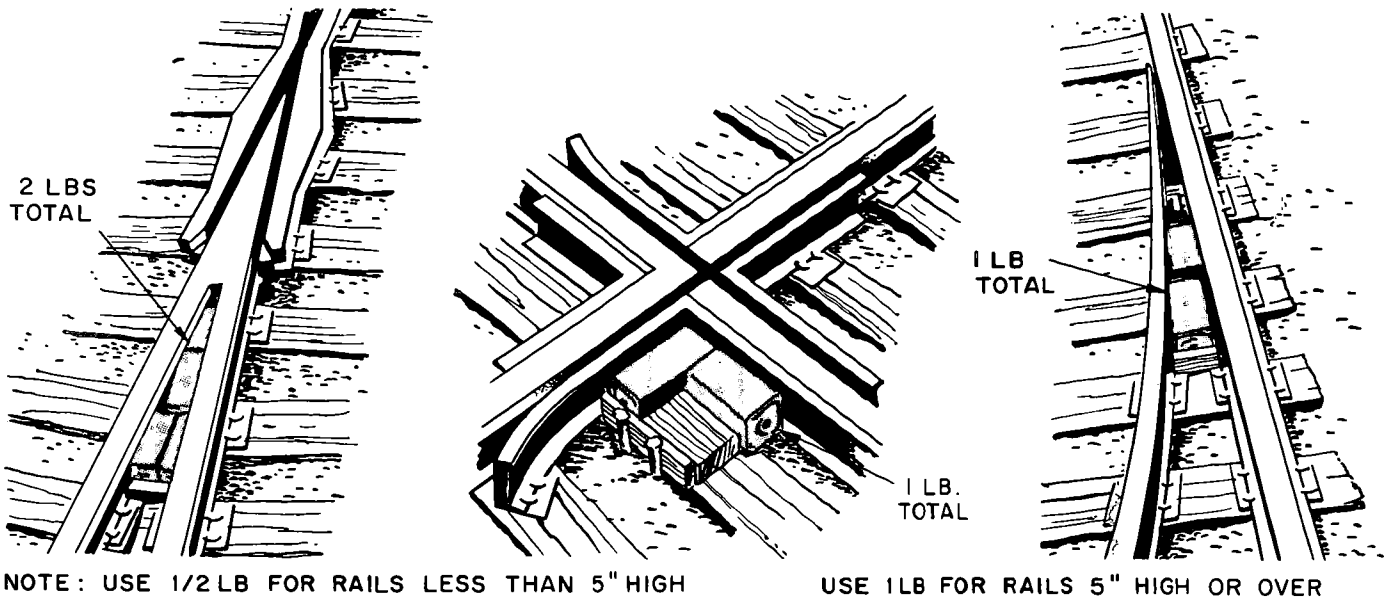



*Figure 4–38. Demolition of railroad switches, frogs, and crossovers.*

method. Placement of charges is shown in figure 4–38.

(2) A length of single track may be destroyed rapidly by a detail of soldiers with a push car, ¼-ton truck, or other vehicle supplied with explosives, nonelectric blasting caps, time blasting fuse, fuse igniters, and filled sandbags. Several soldiers ride the vehicle, prime 1-pound charges, and hand them, together with sandbags, to men walking immediately behind the vehicle. These men place the charges against the rail on alternate connections of both tracks for a distance of about 150 meters, and then tamp them well with sandbags. Tamping is not required to break the rail, but will destroy a longer length of rail. Other men follow about 250 meters behind the vehicle to light the fuses. This method requires approximately 20 pounds of explosive per 150-meter length of single track line. It should be repeated at approximately 1½-mile intervals. Such procedure is particularly advantageous when the supply of explosives is limited or when time or other factors prohibit complete destruction of a line. It causes a greater delay in repair than a concentrated destruction of short lengths of track. If time, explosives and other conditions permit, however, complete destruction of long lengths of track will provide maximum delay.

(3) Tracks may be made unserviceable without the use of explosives by tearing up sections of the track, especially along cuts, fills, or embankments, where the use of reconstruction equipment is restricted and work areas are limited. This may be done by removing fishplates from both ends of a section of track, fastening a heavy chain or cable to it, and pulling it up by a locomotive. Also, a large hook towed by a locomotive is useful to tear up ties and rails. Whenever possible, ties loosened from the rails should be piled and burned.

*b. Roadbeds.* Roadbeds are damaged by the methods used in making road craters and antitank ditches.

*c. Rolling Stock.* The destruction of rolling stock, particularly locomotives, will eventually cause even greater disruption of rail communications.

## 4–41. Railway and Highway Tunnels

Railway and highway tunnels located on major routes to strategic industrial or military areas are vulnerable to demolition and therefore desirable targets. Tunnel demolition, however, with hastily placed conventional explosives is impractical unless huge quantities are used. But when demolition chambers exist or time, men, and equipment are available, considerable damage to tunnels can be accomplished with reasonable amounts of explosive (fig 4–33).

*a. Principal Factors in Tunnel Demolitions.* The most critical factor in tunnel demolition is

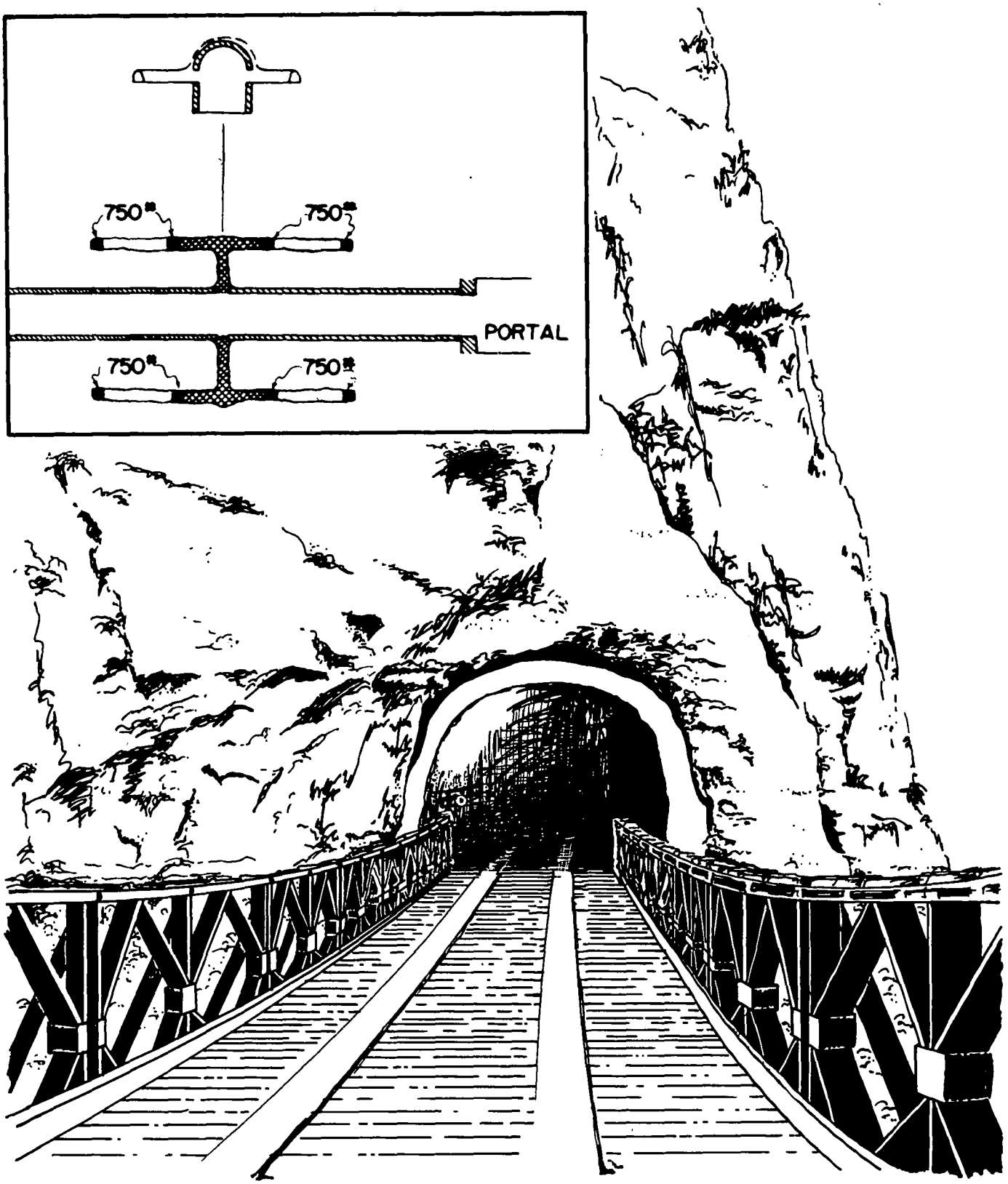



*Figure 4–39. Typical concrete lined tunnel.*

the type of rock through which the tunnel is constructed. As the object of tunnel destruction by demolitions is to block the tunnel with rock and to collapse the tunnel if possible, the best results are obtained if the tunnel is constructed in soft or medium hard rock. In tunnels built in hard rock formations it is difficult to achieve a massive cave-in. As an indication of the type of rock formation through which the tunnel is constructed, the tunnel lining should be examined. A thin or missing tunnel lining usually indicates a hard rock formation.

*b. Hasty Demolitions.* The hasty demolition of tunnels with reasonable amounts of conventional high explosives is ineffective. No hasty method has yet been devised that will cause extensive damage. The enemy may be temporarily deprived of the use of a tunnel by breaking and dislodging portions of the lining with normal breaching charges placed at a number of points and by creating slides at the tunnel portals by placing cratering charges in the slope above them. Nuclear devices of proper size advantageously placed, will effectively demolish a tunnel.

*c. Deliberate Demolitions.* Deliberate tunnel demolitions will produce satisfactory results when explosive charges are detonated in prepared chambers in the material adjacent to the inner face of the tunnel, whether it is lined or not. Excessive charges are not required. Maximum damage desired in any tunnel is its obstruction with broken rock. Caving, which may result from structural damage to the tunnel arch, cannot be predicted. To obtain maximum damage to tunnels, the methods outlined below are adequate.

(1) *Charge chambers.* Tunnel charge chambers (fig 4–39) should be so constructed that each chamber parallels the long axis of the tunnel at or above the spring line. The T-design tunnel charge chamber is an efficient means of inflicting serious damage. The chambers may be constructed opposite each other at staggered intervals on opposite sides, or all on one side of the tunnel. The maximum burden, which is the distance from the charge to the inside rock wall, should be 15 feet. The tunnel charge chamber should be no larger than necessary for convenience of construction and loading and no smaller than 3 feet wide by 4½ feet high. Charge chambers should be constructed far enough inside the tunnel portal to insure confinement of the charge. The minimum of side hill or outside burden should be 30 feet.

(2) *Charges.* Seven hundred and fifty pounds of high explosive is an effective minimum charge for single placement within a T-type chamber of 15-foot burden. Charges should be placed on 30-foot centers.

(3) *Stemming.* Stemming, the material with which a borehole or charge chamber is filled or tamped (usually earthfilled sandbags), is necessary. It should extend from the last charge in the T-type chamber to the chamber entrance. Stemming is not necessary, however, between charges within the chamber.

*d. Deliberate Demolition of Tunnels With Prepared Charge Chambers.* Some tunnels have chambers or holes in the roof or walls, as described above, for the purpose of demolishing them at some future time. Their presence is usually indicated by the open brick ventilators placed over them. If no ventilators are present, these chambers may be located by striking the roof and walls of the tunnel with some heavy metallic object, which usually produces a hollow sound. Some tunnels may also have prepared charge chambers accessible from the outside of the tunnel. These are usually designed for the destruction of the tunnel portals and may be vertical or horizontal shafts dug in the slopes above the tunnel portals. Explosives, compacted as tightly as possible, are placed in the chambers, which are then closed and sealed except for the place where the fuse or firing wire passes through.

## 4–42. Water Transportation Systems

The extent of demolition depends largely upon the mission, materials available, and an analysis of the system as to how critical, accessible, repairable, and vulnerable it may be.

*a. Vessels, Piers, and Warehouses.* Vessels can seldom be destroyed efficiently by landbased troops, unless they are tied up at docks or piers. Docks, piers and warehouses, however, are excellent demolition targets, especially for the use of fire.

*b. Channels.* The most expeditious way to block a channel is to sink a ship or a loaded barge at a point that cannot be bypassed. Channels with retaining walls may be blocked effectively by detonating breaching charges behind the retaining walls.

*c. Dams.* Since a prohibitive amount of explosive is generally required to destroy an entire dam structure, the best and quickest method is to destroy the machinery and the equipment. If

the purpose of the demolition is to release the water in the dam, all that is required is to destroy the gates on the crest of the dam, the penstocks or tunnels used to bypass the dam or to carry water to hydroelectric plants, or the valves or gates used to control the flow in the penstocks or tunnels. In dams, partly or wholly constructed of earth fill, it may be possible to ditch or crater down below the existing waterline and thus allow the water itself to further erode and destroy the dam. Nuclear devices may also be used to advantage.

*d. Canals.* In most cases, a canal may be made useless by destroying the lock gates and the operating mechanism that controls them. This mechanism, which includes the electrical equipment and perhaps pumps, is the easier to destroy and should therefore be attacked first. If time permits, the gates themselves may be destroyed. The lock walls and canal walls may be destroyed by breaching charges or cratering charges placed behind them.

## 4–43. Airfields

Airfields may be destroyed by ADM. They may be rendered unusable by cratering runways or placing objects on surfaces to prevent use by aircraft. The destruction of POL and munitions stocks and of repair and communications facilities is also desirable. Rooters, plows, and bulldozers can ditch runways that are not constructed of concrete. Friendly operational and nonoperational airfields should be destroyed only in areas where the resulting wreckage will provide the maximum impediment to enemy movement and operations. They should, however, be made ready for demolition only during the preparation for an organized withdrawal when seizure by the enemy is imminent.

*a. Plans for Demolition.*

(1) The methods of destroying an airfield depend on the materials at hand, the type of installation to be destroyed, and the time and equipment available to complete the job. Aircraft and equipment may be destroyed instantly by directing weapons fire against them. Whenever possible, bombs and ammunition should be used as explosive charges (app. C). Gasoline and other fuels (POL products) may be used to aid in the destruction, by fire, of vehicles, equipment, and buildings.

(2) When time permits, a detailed plan for demolition of the airfield should be prepared before any charges are placed. This should include—

(*a*) Location of charges.

(*b*) Type of explosives.

(*c*) Size of each charge.

(*d*) Priority in preparation and placement of each charge.

(*e*) Total amount of itemized explosives and other materials needed to effect demolitions included in the plan.

(*f*) Assignment of personnel or groups to prepare specific charges.

*b. Priorities for Demolition.* It is seldom possible to destroy an airfield completely because of the great amount of explosives and time required. Thus it is necessary to determine what specific demolition is to be done and in what order specific operations are to be accomplished. Airfield demolition plans should be very flexible, particularly in regard to priorities. The order of priority should vary according to the tactical situation. The following list suggests an order of priority for airfield demolition, which may be modified to suit the tactical situation.

(1) Runways and taxiways and other landing areas.

(2) Routes of communication.

(3) Construction equipment.

(4) Technical buildings.

(5) Supplies of gasoline, oil, and bombs.

(6) Motor vehicles and unserviceable aircraft.

(7) Housing facilities.

*c. Runways and Taxiways.* Runways and taxiways have first priority in a demolition plan because the destruction of landing surfaces is the most important single item. Whenever possible, demolition of an airfield should be considered during construction by the placing of large conduits in all fills. This requires little extra work and provides a means of placing explosives under the runway. Standard deliberate and hasty craters may be useful in the demolition of runways and taxiways. Shaped charges may be used to breach thick concrete pavement when speed is essential. The placing of individual cratering charges diagonally down the runways or taxiways, or in a zigzag line running diagonally back and forth, provides more complete destruction. When pierced steel plank or other type of landing mat is used on an airfield, substantial damage may be done by attaching a large hook to sections of the mat and pulling it out of place

with a tractor. This should be followed by cratering. A hasty, satisfactory obstacle may be produced by the use of 40-pound cratering charges spaced every 15 feet across the runway and buried 4 feet under the ground.

*d. Turf Surfaces and Pavements.* Bituminous surface treatments or thin concrete pavements can be destroyed by bulldozers, graders, and rooters. Turf airstrips can be destroyed by plowing or cratering.

*e. Aircraft.* Unserviceable aircraft should be destroying by the detonation of 4 pounds of TNT placed on each crankshaft between the propeller and the engine and 1 pound of TNT placed on the instrument panel to prevent salvage. The engines of jet-propelled aircraft should be destroyed by detonating charges on essential parts, such as the compressor, air intake, or the exhaust turbine. Radio equipment, bombsights, radar, and tires should be removed or destroyed.

### 4–44. Pipelines

The most vulnerable points of a pipeline system are the storage tanks and pumping stations.

*a. Storage Tanks.* Storage tanks filled with fuel may be destroyed most effectively by burning with incendiary grenades or a burst of .50-caliber incendiary ammunition. Empty tanks may be destroyed by detonating charges against the base.

*b. Pumping Stations.* Booster pumping stations on cross-country pipelines, being very vulnerable, should be destroyed. Gravel or other solid objects introduced into the pipeline while the pumps are running will damage the moving parts, although not to the degree possible with explosives. If time permits, the pumping station should be burned after the equipment has been destroyed by explosives.

*c. Pipe.* The pipe used in pipelines is destroyed only during scorched earth operations because of the great amount of effort necessary for effective damage. Junctions, valves, and bends are the most suitable points, particularly when the line is buried. Another method is to close all valves on the line; the expansion that occurs, even in subzero weather, will break it.

## Section V. DAMAGING COMMUNICATION SYSTEMS

### 4–45. Telephone and Telegraph Lines

Although damage to an enemy telephone system or telegraph system may never be extensive, it does have a great delaying effect. Telephone and telegraph switchboards and instruments are the best points of attack. Generally 1-pound charges placed on the cables are adequate to sever them. Also dial systems may be damaged by smoke from burning oil. Pole lines are not satisfactory targets as they are strung over long distances and can be destroyed only in spots. They may be made temporarily useless by cutting or grounding the wires or by cutting the poles with small external timber-cutting charges and then burning. The wire should be cut into short lengths to prevent further use.

### 4–46. Radio Installations

Radio provides rapid communication between far distant points that would otherwise be without communication. Antenna towers, usually constructed of steel and braced with guy wires, are the most accessible part of any radio installation. They are destroyed by cutting the guy wires and placing cutting charges against the base. The towers should be toppled over the transmitter station or across the high voltage transmission line through which the installation received its power. Equipment and standby power units may be destroyed by mechanical means or by demolition charges. Transformers also are very vulnerable. They will burn themselves up if a hole is blasted in the side or bottom and the oil let out, provided they do not have automatic thermo cutoff switches.

## Section VI. DESTRUCTION OF BUILDINGS AND INSTALLATIONS

### 4–47. Buildings

Buildings may be destroyed by explosive or other methods. The methods used and the extent of demolition usually depend on the time available.

*a. Masonry or Concrete Buildings.* Masonry or concrete buildings may be destroyed by breaching charges placed on the inside and at the base of the exterior walls.

*b. Wood or Thin-Walled Buildings.* Wooden frame buildings may readily be destroyed by fire. Another method is to close all doors and windows and explode on the ground floor a concentrated charge (dust initiator) equal to ¼ pound to 1 pound of explosive per cubic yard of volume (app D). Such buildings may be dismantled, however, if time permits.

*c. Steel Framed Buildings.* Buildings with steel frames may be destroyed by first breaching the concrete or masonry where necessary to expose the vital steel members and then cutting them with explosive charges. Another method, the exposure of the interior to extreme heat, (1000° F. for 10 minutes) will cause failure of the structural steel members.

*d. Concrete Beam, Curtain Wall Buildings.* Concrete beam curtain wall buildings, constructed in such a way that the load is carried by reinforced concrete beams and columns, are destroyed by placing breaching charges inside the buildings at the base of the exterior wall and at the base of all intermediate columns on the ground floor.

### 4–48. Electrical Power Installations

*a. Electric Power Plants.* Before destruction, electric power plants should be studied so that the amount of damage will be adequate but not exceed tactical demands. They may be destroyed by cutting the windings of generators and motors, by placing and detonating a 2-pound charge inside the casings, or by pouring gasoline on the generators and lighting them. Generators also may be "shorted" out by the use of metal powder or shavings. The shafts of motors and generators are broken. Damage can also be done by removing or contaminating the lubricating oil with metal filings or aluminum powder and then running the machinery. Boilers are burst with a cutting charge. All buildings, transmission towers, penstocks, and turbines of hydroelectric plants may be destroyed.

*b. Transmission and Distribution Facilities.*

(1) Transmission lines may be destroyed by cutting or by demolishing the towers or poles. However, the complete disruption of electrical power by this method is difficult as electrical power is usually supplied by more than one power line.

(2) Electrical substations may be profitably attacked by destroying transmission lines and switching equipment. Large transformers are very vulnerable. They will burn themselves up if the cooling oil is drained out. This may be accomplished with explosives or weapons fire.

*Note.* Electric firing systems should not be used (para 2–9).

### 4–49. Water Supply

The pumping station, filtration plant, and reservoirs of a water supply system are usually the points most accessible to attack. Storage tanks are demolished by charges calculated on the basis of 1 pound of explosive per 100-cubic foot capacity. The charge is detonated inside the tank when it is full of water. The water acts as a tamping material. Shaped charges are also useful in this capacity. The standoff, however, should be cut down considerably. Wells sunk in soft soils are damaged beyond repair by charges that cut the lining. Wells in rock and hard soils, having little or no lining, are demolished by exploding large breaching charges 6 to 12 feet from the edge of the well and deep enough to secure good tamping. If time does not permit such preparation, a large charge is exploded halfway down against the side.

### 4–50. Petroleum, Oil and Lubricating Refineries

POL refineries are readily demolished, having such extremely vulnerable points as cracking towers, steam plants, cooling towers, and POL stock. These are easily damaged by explosive charges and fire. The demolition of such installations should be planned and executed only by persons familiar with their design and construction or after extensive investigation.

## Section VII. DESTRUCTION OF FORTIFICATIONS

### 4–51. General

The destruction of field fortification to prevent their use or reuse by enemy forces, as with all other demolition projects, depends upon the material from which they are constructed, and the time, equipment, material and manpower available. As field fortifications are of many types, from observation towers to underground bunkers, and may be constructed of many types of materials, from earthfilled sandbags to reinforced concrete, the calculation of a standard method for destruction by use of explosives is almost impos-

sible. For the demolition of obstacles see FM 5–29.

### 4–52. Bunkers

*a. Above Ground or Semi-Buried.* Bunkers which are above ground or partially above ground are accessible to men and may be dismantled or may be collapsed by heavy equipment. Explosives may also be used to breach the roof of the bunker or to cut the structural members which support the roof.

*b. Underground.* Bunkers which are wholly below the ground are best destroyed by the use of explosives. The explosives are placed to breach the ceiling of the bunker or to cut the structural support of the ceiling. If time permits, the construction and use of demolition chambers, similar to the methods used in railway and highway tunnel destruction, may be advantageous.

### 4–53. Trenches

Trenches may be filled by hand or by equipment. The use of explosive charges to collapse the walls may be required when trench walls are supported with timber or other materials, however, large quantities of explosives may be required.

### 4–54. Tunnels and Caves

*a. Caves.* Caves are destroyed by collapsing the walls and ceiling or the entrance using the methods outlined for highway and railroad tunnel destruction.

*b. Tunnels.* Tunnels used to connect underground bunkers may be collapsed along their entire length or may be partially destroyed by collapsing the tunnel entrances. Because tunnels may vary in size and construction and the soil conditions vary widely even within the same tunnel, the use of test shots is necessary. For unlined tunnels, in earth, not over two meters in diameter, the following rule of thumb may be used to determine the amount of explosive needed for a test shot. Use two pounds of explosive per linear foot of tunnel for 10 feet or less of overburden (depth of earth above tunnel). For each additional 10 feet or less of overburden, an additional two pounds of explosive per linear foot of tunnel is recommended. The explosive charges should be disbursed along the entire length and tied together with detonating cord. For maximum destructive effect, charges should be placed against the ceiling and all tunnel entrances filled in. The use of additional explosives at turns, intersections, and branches of the tunnel may be necessary. If the size and construction of the tunnel and local soil conditions vary from those given above, the amount of explosives used for the test shot must be adjusted.

## Section IX. DESTRUCTION OF EQUIPMENT AND SUPPLIES

### 4–55. Introduction

*a. Authority for Destruction.* The destruction of friendly materials is a command decision, implemented only on authority of the division or higher commander. Equipment and supplies that cannot be evacuated and may, therefore, be captured by the enemy are destroyed or made unserviceable, except for medical materials and stores, which are not to be intentionally destroyed (DA Pam 27–1 and FM 8–10).

*b. Destruction Areas.* Whenever possible, mobile equipment is demolished in places where it most effectively impedes the advance of the enemy. Examples of such places are—

(1) Approaches to bridges (fills).

(2) Airfield landing strips.

(3) Cuts, fills, or hills on roads.

(4) Sharp bends of roads.

(5) Roads leading through densely wooded areas.

(6) Narrow streets in thickly populated or built-up areas.

*c. Priority of Operations.* Destruction must be as complete as the available time, equipment, and personnel will permit. If all parts of the equipment cannot be completely destroyed, the most important ones should be damaged. Special attention must be given to those parts that are not easy to duplicate or rebuild. Particular care must be taken that the same components are destroyed on each piece of equipment; otherwise the enemy may assemble a complete unit with parts taken from several partly destroyed units (cannibalization).

*d. Precautions.* When material is destroyed by explosives or by weapons fire, flying fragments and ricocheting bullets create a hazard. Thus demolition must be accomplished in an area free of friendly troop concentrations.

## 4–56. Planning

Standing operating procedures for all units should contain a plan for the destruction of all equipment and supplies except medical supplies, which are left intact for enemy capture. Such a plan will insure that the maximum and most effective damage is done to materiel and will deny the use of friendly equipment to the enemy. It should outline the required extent of demolition and include priorities of demolition and methods of destruction for all items issued to the unit. If explosives are to be used, the amounts required should be indicated. The plan must be flexible enough in its designation of time, equipment, and personnel to meet any situation. In order to make cannibalization by the enemy impossible, each equipment operator must be familiar with the priority sequence in which essential parts, including extra repair parts, are to be destroyed. He must also be familiar with the sequence to be followed for total destruction.

## 4–57. Methods of Destroying Material

The following methods of destroying material may be used either singly or in combination. The actual method or methods used in a given situation depend on the time, personnel, and means available.

*a. Explosives.* All military explosives are effective in destroying equipment.

*b. Mechanical Means.* Material may be destroyed by mechanical means. Sledge hammers, crowbars, picks, axes, and any other available heavy tools are used to smash or damage whatever is to be destroyed.

*c. Weapons Fire.* Hand grenades, rifle grenades, antitank rockets, machinegun fire, and rifle fire are a valuable means of destroying materiel.

*d. Thermite Grenades.* Flammable material and equipment may be destroyed or made unserviceable by heat generated by the thermite grenade. The material should be soaked with fuel before burning.

*e. Fire.* Rags, clothing, or canvas should be packed under and around the materiel to be destroyed. It should then be soaked with gasoline, oil, or diesel fuel. Damage from fire may not always be as severe as expected. Engine or transmission parts heated to less than a dull red heat are not seriously damaged provided they are lubricated immediately after the fire to prevent corrosion. Electrical equipment, including motor or generator armature windings and other wiring, is effectively destroyed by burning. All parts made from low-melting-point metal may be almost completely destroyed by fire.

*f. Water.* The damage resulting from submerging equipment in water is not generally very severe, but the method is sometimes rather quickly and easily accomplished. Total submersion also provides concealment of equipment (*h* below).

*g. Abuse.* Much damage can be done to equipment, particularly to engines, by deliberate improper operation. Such abusive treatment may proceed even after abandonment, if hasty action becomes necessary, by draining the oil and leaving the equipment operating at a high idle speed.

*h. Concealment.* Easily accessible vital component parts of equipment may be removed and scattered through dense foliage, thus preventing or at least delaying use by the enemy. Vital parts of entire items may be hidden by throwing them into a lake, stream, or other body of water (*f* above).

*i. Boobytrapping.* Boobytraps are placed in debris after destruction is completed, if time permits. See FM 5–31 for the techniques.

## 4–58. Destruction of Combat Equipment

There are various publications on the proper methods of destroying military combat equipment. The FM 23-series is concerned with the destruction of small arms such as rifles, mortars, and ammunition; and the FM 17-series with the destruction of armored vehicles and their weapons. For destruction of demolition materials see chapter 5.

## 4–59. Training

Training does not involve the actual demolition of any materiel but the simulated breaking of vital parts, the placing of dummy charges, and the selection of sites suitable for the destruction of equipment in order to block communication routes. Drivers and operators should be made familiar with each step in the appropriate method for the destruction of their equipment and supplies. It should be emphasized that in planning destruction operations, the following methods should be considered as preferable in the order given:

*a.* Mechanical damage to vital parts.

*b.* Use of explosives.

*c.* Use of weapons fire, fire, and water.

# CHAPTER 5

# SAFE HANDLING, TRANSPORTATION, STORAGE AND DESTRUCTION OF EXPLOSIVES

## Section I. GENERAL SAFETY PRECAUTIONS

### 5–1. Safety Rules and Responsibility

*a. Compliance.* Safety rules regarding explosives, caps, and demolition equipment will be followed strictly during training. In combat, however, some must of necessity be altered so that unit missions may be accomplished. In all other situations they will be observed to the fullest extent permitted by time, materials available, and requirements of the mission. Also, post regulations and local and units SOP's will be observed.

*b. Responsibility.* The responsibility for the preparation, placement, or firing of charges must not be divided. One individual should be responsible for the supervision of all phases of the demolition mission.

### 5–2. Safe Distance From Demolitions

*a. Blast Effect.* Generally, the greater danger to personnel is the missiles thrown by the explosion. Blast effect, (the increase in air pressure) is a hazard only where special protective features are used at detonation or demolition sites to eliminate or confine missiles and provide for detonation of charges close to personnel. Personnel provided the minimum protection prescribed in *c* below will not generally be endangered by blast effects. See AR 385–63.

*b. Missile Hazard.* Explosives can propel lethal missiles great distances. How far an explosion-propelled missile will travel in air depends primarily upon relations between weight, shape, density, initial angle of projection, and initial speed. The missile hazard from steel cutting charges extends a greater distance under normal conditions than that from cratering, quarrying or surfaces charges of bare explosives.

*c. Safe Distances.*

(1) The following criteria give the missile hazard distances at which personnel in the open are relatively safe from missiles created by bare charges placed in or on the ground, regardless of type or condition of the soil (AR 385–63).

(*a*) For charges less than 27 pounds, the minimum missile hazard distance is *300 meters.*

(*b*) For charges from 27 to 425 pounds, the distance at which personnel in the open are relatively safe from missiles can be calculated from the formula: *safe distance* in meters = *100* × $\sqrt[3]{}$*pounds of explosive.* Safe distances calculated for selected charge weights are given in table 5–1.

(*c*) For charges over 425 pounds, the minimum missile hazard distance is *750 meters.*

(2) For charges placed to demolish solid material, missile-proof shelters should be provided a minimum distance of *100 meters* away from the demolition site. These shelters should be of sufficient strength to withstand the heaviest material which might be thrown on them.

*Table 5–1. Minimum Safe Distance for Personnel in the Open*

| Pounds of explosive | Safe distance in meters | Pounds of explosive | Safe distance in meters |
|---|---|---|---|
| 1 to 27 | 300 | 150 | 534 |
| 30 | 311 | 175 | 560 |
| 35 | 327 | 200 | 585 |
| 40 | 342 | 225 | 609 |
| 45 | 356 | 250 | 630 |
| 50 | 369 | 275 | 651 |
| 60 | 392 | 300 | 670 |
| 70 | 413 | 325 | 688 |
| 80 | 431 | 350 | 705 |
| 90 | 449 | 375 | 722 |
| 100 | 465 | 400 | 737 |
| 125 | 500 | 425 and over | 750 |

### 5–3. Package Care and Repair

Carelessness, rough handling, and disregard for safety rules cause premature explosions, misfires, and in many cases serious accidents. Issued ex-

plosives and auxiliary items are packed in moisture-resistant containers and proper packing boxes to withstand field conditions of transportation and storage. Containers and boxes must never be handled roughly; they must never be broken, cracked, or dented. Some special items, if distorted, lose part of their effectiveness. Damaged packing boxes and containers must be repaired immediately; all defaced parts of marking must be transferred to new parts of the boxes. Broken airtight containers, such as those containing chemical mines, should be destroyed. For detailed information on care and handling of explosive items see TM 9–1300–206.

### 5–4. Reports of Malfunction

Explosives are identified by lot number. If frequent misfires or failures or malfunctions are noted, the lot number of the malfunctioning item should be noted, and reported in accordance with AR 75–1.

## Section II. TRANSPORTATION AND STORAGE

### 5–5. Transportation Regulations

Transportation of military explosives and other dangerous military articles by either military or commercial carriers within the United States is governed by AR 55–355. Transportation in military vehicles over public highways are subject to all laws, rules, and regulations applicable to commercial carriers. AR 55–228 contains regulations governing transportation by water of military explosives, flammables, and chemical materials. TM 9–1300–206 contains minimum safety requirements for the handling and transportation of military explosives and ammunition. Local safety SOP's must be provided to insure that all persons participating in the transportation of explosives have proper instruction in safety requirements and are held to account for all violations of procedure.

### 5–6. General Rules

The following safety rules will be observed whenever explosives are to be transported for local use:

*a.* Vehicles used for the transportation of explosives shall not be loaded beyond rated capactiy and the explosives shall be secured to prevent shifting of load or dislodgment from the vehicle in transit. In all open-body types of vehicles the explosives shall be covered with a fire-resistant tarpaulin.

*b.* All vehicles transporting explosives shall be marked with reflectorized placards on both sides and ends with the word EXPLOSIVES in white letters not less than 6-inches high on a red background.

*c.* Blasting caps or other initiators shall not be transported in the same vehicle with other explosives, if possible; otherwise the caps should be carried in the front and the explosives in the rear of the truck.

*d.* All vehicles used for transportation of explosives shall be in charge of, and operated by, a person who is of mature mind, physically fit, careful, reliable, able to read and write the English language, and not addicted to the use of intoxicants or narcotics. He should be aware of the destructive effects of explosives.

*e.* No metal tools, carbides, oils, matches, firearms, electric storage batteries, flammable substances, acids, or oxidizing or corrosive compounds shall be carried in the bed or body of any vehicle transporting explosives.

*f.* Vehicles to be used in the transportation of explosives shall be in good repair. When steel or part steel bodies are used, fire-resistant and nonparking cushioning materials shall be employed to separate the containers of explosives from the metal.

*g.* Vehicles transporting explosives shall be equipped with not less than two fire extinguishers placed at strategic points, filled and ready for immediate use, and of a make approved by the National Board of Fire Underwriters for class B and C fires.

*h.* A vehicle containing explosives shall not be taken into a public building or repair shop or parked in congested areas.

*i.* All vehicles shall be checked before transporting explosives and all electric wiring completely protected and securely fastened to prevent short circuiting.

*j.* Vehicles transporting explosives shall be operated with extreme care and shall not be driven at a speed greater than 35 miles per hour. Full stops shall be made at approaches to all railroad crossings and main highways, and the vehicle

shall not proceed until it is known that the way is clear. This, however, does not apply to convoys or protected crossings manned by highway flagmen or guards.

*k.* All vehicles transporting explosives on pullic highways, roads, or streets shall have an authorized driver and helper. No person other than the authorized driver and helper shall be permitted to ride on a truck transporting explosives. No motor vehicle shall be refueled while explosives are on the vehicle except in an emergency.

## 5–7. Magazines

*a. Types.* Explosives are stored in magazines according to the safety regulations prescribed in TM 9–1300–206 and FM 9–6. Table 5–2 indicates the minimum distance for the location of magazines from other magazines, buildings, and routes of communication based on the quantity of explosives stored. There are two types of magazines—permanent and temporary. Although the permanent type is preferred, temporary or emergency types are frequently required when permanent construction is not possible.

*Table 5–2. Magazine Locations (Unbarricaded)*

| Quantity, pounds of explosives (not over) | Minimum distance in feet from nearest— | | |
|---|---|---|---|
| | Inhabited building | Public highway and public railroad | Magazine |
| 50 | 300 | 180 | 60 |
| 100 | 380 | 230 | 80 |
| 500 | 640 | 380 | 140 |
| 1,000 | 800 | 480 | 190 |
| 2,000 | 1,010 | 610 | 230 |
| 4,000 | 1,270 | 760 | 280 |
| 6,000 | 1,460 | 880 | 320 |
| 8,000 | 1,600 | 960 | 360 |
| 10,000 | 1,730 | 1,040 | 400 |
| 20,000 | 1,950 | 1,170 | 490 |
| 40,000 | 2,550 | 1,530 | 620 |
| 60,000 | 3,030 | 1,820 | 700 |
| 80,000 | 3,390 | 2,035 | 780 |
| 100,000 | 3,630 | 2,180 | 830 |
| 200,000 | 4,060 | 2,435 | 1,050 |
| 500,000 | 5,410 | 3,245 | 1,430 |

*Note.* For more detailed information see TM 9–1300–206.

*b. Barricades.* Explosives storage magazines must be barricaded, that is, have a substantial obstacle between them and inhabited buildings. For certain explosives, effective natural or artificial barricades reduce by one-half the distance necessary between magazines, railways, and highways. The use of barricades thus permits the storage of larger quantities of explosives in any given area. Although barricades help protect magazines against explosives and bomb or shell fragments, they are no safeguard against pressure damage.

*c. Other Considerations.* Magazines are usually placed at locations determined according to safety, accessibility, dryness, and drainage. Safety and accessibility, however, are the most important. An ideal location is a hilly area where the height of the ground above the magazine provides a natural wall or barrier to buildings, centers of communication, and other magazines in the area. Sidehill dugouts are not desirable, as adequate ventilation and drainage are often hard to provide. Brush and tall grass should be cleared from the site to minimize the danger of fire.

*d. Lightning Protection.* All magazines must have a grounded overhead lightning rod system. Also, all metal parts—doors, ventilators, window sashes, and reinforcing steel—must be connected in several places to buried conduits of copperplate or graphite rods.

## 5–8. Field Expedient Structures

*a.* Field expedients for the storage of explosives when magazine construction is not possible are—

(1) A dugout excavated in a dry area and revetted with timber to prevent caving, and well drained.

(2) An isolated building.

(3) A light wooden frame box house, with a wedge type roof covered by corrugated iron, or merely covered with a tent or canvas tarpaulin. The explosives should be placed on pallets for all-around ventilation.

*b.* Field expedient storage facilities should be appropriately marked by signs on all four sides, and guarded.

## 5–9. Temporary Magazines and Storage

Limited supplies of explosives can be stored for several days when necessary in covered ammunition shelters and should be so separated that fire or explosion cannot be transmitted from one shelter to another. Piles of explosives temporarily stored in the open should contain no more than 500 pounds, and be placed no less than 140 feet apart. Explosive components should be piled separately. Explosives, caps, and other demolition material stored temporarily in training areas should be kept separate in covered ammunition shelters, and under guard at all times. Temporary storage operations should be guided by local safety SOP's and other regulations (TM 9–1300–206).

## Section III. DESTRUCTION TO PREVENT ENEMY USE

### 5–10. General

*a.* The destruction of damaged or unserviceable explosives and demolition materials is accomplished by explosive ordnance disposal units as specified in AR 75–14, AR 75–15, TM 9–1375–200 and FM 9–16.

*b.* Destruction of demolition materials, when subject to capture or abandonment, will be undertaken by the using arm only when, in the judgment of the unit commander concerned, such action is necessary in accordance with orders of, or policy established by, the Army commander. The conditions under which destruction will be effected are command decisions and may vary in each case, dependent upon a number of factors such as the tactical situation, security classification of the demolition materials, their quantity and location, facilities for accomplishing destruction, and time available. In general, destruction can be accomplished most effectively by burning or detonation, or a combination of these.

*c.* If destruction to prevent enemy use is resorted to, explosive and nonexplosive demolition materials must be so completely destroyed that they cannot be restored to usable condition in the combat zone. Equally important, the same essential components of sets and kits must be destroyed so that the enemy cannot assemble complete ones from undamaged components by cannibalization.

*d.* If destruction of demolition materials is directed, due consideration should be given to (1) and (2) below.

(1) Selection of a site that will cause greatest obstruction to enemy movement and also prevent hazard to friendly troops from fragments and blast which will occur incidental to the destruction.

(2) Observation of appropriate safety precautions.

### 5–11. Destruction Methods

Demolition materials can be most quickly destroyed by burning or detonation. The methods in *a* and *b* below, in order of preference, are considered the most satisfactory for destruction of demolition materials to prevent enemy use. For additional information on the destruction of explosives and ammunition see TM 9–1300–206 and TM 9–1300–214.

*a. Method No. 1—By Burning.*

(1) *General.* Packed and unpacked high-explosive items such as linear demolition charges, shaped demolition charges, block demolition charges, dynamite sticks, detonating cord, firing devices, time blasting fuse, and similar items may be destroyed quickly and effectively by burning. Blasting caps set aside for destruction by burning must be stacked in separate piles and not with other explosives.

(2) *Method of destruction.*

(*a*) Stack the explosives in a pile, if possible (not over 2,000 pounds to a pile), over a layer of combustible material.

(*b*) Pour *fuel oil* over the entire pile.

(*c*) Ignite the pile by means of a combustible train (excelsior or slow-burning propellant) of suitable length and take cover immediately. The danger area for piles being burned in the open is calculated from the safe distances given in paragraph 5–2 but never less than 400 meters.

***Warning.* Cover must be taken without delay, since detonation of the explosive material may be caused by the fire.**

*b. Method No. 2—By Detonation.*

(1) *General.* Packed and unpacked high-explosive items such as linear demolition charges, shaped demolition charges, block demolition charges, dynamite sticks, detonating cord, blasting caps, firing devices, time blasting fuse, and similar items may be destroyed by placing them in piles and detonating them with initiating charges of TNT, or composition C series explosives, or other explosives having equivalent potential.

(2) *Method of destruction.*

(*a*) The explosives should be stacked in piles, if possible (not over 2,000 pounds to a pile).

(*b*) Each 100 pounds of packed explosives (mine, blocks, etc.), require a 2-pound (minimum) explosive charge to insure complete detonation of the pile. For unpacked explosives, a 1-pound (minimum) explosive charge for each 100 pounds is sufficient.

(*c*) Provide for dual priming as explained in chapter 2 to minimize the possibility of a misfire. For priming, either a nonelectric blasting cap crimped to at least 5 feet of time blasting fuse or an electric cap and firing wire may be used.

(*d*) Detonate the charges. If primed with

nonelectric blasting cap and time blasting fuse, ignite and take cover; if primed with electric blasting cap, take cover before firing the charges.

The danger area for piles detonated in the open is calculated according to the safe distance given in paragraph 5–2.

# APPENDIX A

# REFERENCES

## A–1. Army Regulations (AR)

| | |
|---|---|
| 55–228 | Transportation by Water of Explosives and Hazardous Cargo. |
| 55–355 | Military Traffic Management Regulation. |
| 75–1 | Malfunctions Involving Ammunition and Explosives (RCS AMC–132). |
| 75–14 | Responsibilities for Explosives Ordnance Disposal. |
| 75–15 | Responsibilities and Procedures for Explosive Ordnance Disposal. |
| 310–25 | Dictionary of United States Army Terms. |
| 310–50 | Authorized Abbreviations and Brevity Codes. |
| 385–63 | Regulations for Firing Ammunition for Training, Target Practice and Combat. |

## A–2. Field Manuals (FM)

| | |
|---|---|
| 5–26 | Employment of Atomic Demolition Munitions (ADM). |
| 5–29 | Passage of Mass Obstacles. |
| 5–30 | Engineer Intelligence. |
| (C) 5–31 | Boobytraps (U). |
| 5–34 | Engineer Field Data. |
| 5–35 | Engineers' Reference and Logistical Data. |
| 5–36 | Route Reconnaissance and Classification. |
| 9–16 | Explosive Ordnance Reconnaissance. |
| 20–32 | Landmine Warfare. |
| 20–33 | Combat Flame Operations. |
| 30–5 | Combat Intelligence. |
| 31–10 | Denial Operations and Barriers. |
| 31–20 | Special Forces Operational Techniques. |
| 31–45 | Explosive Ordnance Disposal Service. |

## A–3. Technical Manuals (TM)

| | |
|---|---|
| 5–220 | Passage of Obstacles other than Minefields. |
| 5–280 | Foreign Mine Warfare Equipment. |
| 5–332 | Pits and Quarries. |
| 9–1300–200 | Ammunition, General. |
| 9–1300–206 | Care, Handling, Preservation and Destruction of Ammunition. |
| 9–1300–214 | Military Explosives. |
| 9–1345–200 | Land Mines. |
| 9–1375–200 | Demolition Materials. |
| 9–1375–202–10 | Operator's Manual: Demolition Kit, Projected Charge, M173. |
| 9–1375–203–15 | Operator, organizational maintenance, direct support, general support and depot maintenance manual including repair parts and special tool lists: Electric Blasting Equipment. |
| 9–1375–204–10 | Operator's Manual: Demolition Kit, Projected Charge, M157. |
| (C) 31–200–1 | Unconventional Warfare Devices and Techniques References (U). |

## A–4. Department of the Army Pamphlets (DA Pam)

| | |
|---|---|
| 310-series | Military Publications Indexes (as applicable). |

# APPENDIX B

# METRIC CHARGE CALCULATIONS

## B–1. Introduction

The following metric equivalent charge calculation formulas are included because of NATO requirements. Problems, solutions, and tables with measurements converted to the metric system are given below.

## B–2. Characteristics of Demolition Charges

The characteristics of the standard U.S. Army demolition charges, expressed in the metric system are given in table B–1.

## B–3. Timber Cutting Formulas

*a. Tamped Internal Charges.*

(1) *Formula:* $K = \frac{D^2}{3500}$ where,

$K$ = Kilograms of TNT required,
$D$ = Diameter of timber in centimeters, and
3500 = constant.

(2) *Example:* (fig 3–1)

$$K = \frac{D^2}{3500}$$
$$K = \frac{35^2}{3500} = \frac{1225}{3500}$$
$$K = .350 \text{ kg};$$

Use .454 kg (1 lb) of TNT

*b. Untamped External Charges.*

(1) *Formula:* $K = \frac{D^2}{560}$ where,

$K$ = Kilograms of TNT required,
$D$ = Diameter of timber in centimeters, and
560 = constant.

(2) *Example:* A timber is 30 centimeter thick.

$$K = \frac{D^2}{560}$$
$$K = \frac{30^2}{560} = \frac{900}{560}$$
$$K = 1.61 \text{ kg},$$

Use 1.816 kg (4 lb) of TNT

*Table B–1. Characteristics of Principal U.S. Explosives (Metric)*

| Item | Detonating velocity (meters per sec) | Relative effectiveness | Weight per block (kilograms) |
|---|---|---|---|
| TNT block, ¼ lb. | 6,900 | 1.00 | .113 |
| TNT block, ½ lb | | | .227 |
| TNT block, 1 lb | | | .454 |
| M2 block, 2½ lb Tetrytol | 7,000 | 1.20 | 1.134 |
| M3 block, 2¼ lb, C2 or C3 | 7,625 | 1.34 | 1.021 |
| M5A1 block, 2½ lb, Comp C4 | 8,040 | 1.34 | 1.134 |
| M112 block, 1¼ lb, Comp C4 | 8,040 | 1.34 | .567 |
| M118 block, 2 lb, (PETN) | 7,040 | 1.14 | block—.907 kg sheet—.113 kg |
| M186 roll, 25 lb (PETN) | 7,040 | 1.14 | roll—11.34 kg sheet—744. gm per meter or 1.00 kg per 1.34 meters |
| Ammonium nitrate, 40-lb, cratering charge. | 3,400 | 0.42 | 18.14 |
| M1 military dynamite, ½ lb | 6,100 | 0.92 | .227 |
| M2A4, 15-lb shaped charge | NA | NA | 6.80 |
| M3A1, 40-lb shaped charge | NA | NA | 18.14 |
| M183 demolition charge assembly | NA | 1.34 | 9.07 |

*c. Abatis Charge.*

(1) *Formula:* $K = \frac{D^2}{700}$ where,

$K$ = Kilograms of TNT required,
$D$ = Diameter of tree in centimeters, and
700 = constant.

(2) *Example:* A tree is 45 centimeters in diameter.

$$K = \frac{D^2}{700}$$
$$K = \frac{45^2}{700} = \frac{2025}{700}$$
$$K = 2.89 \text{ kg of TNT}$$
$$K(C4) = \frac{2.89}{1.34} = 2.16 \text{ kg of C4}$$

Use 2.268 kg (5 lb) of C4.

## B–4. Steel Cutting Formulas

*a. Structural Steel.*

(1) *Formula:* $K = \frac{A}{38}$ where

$K$ = Kilograms of TNT required,
$A$ = Cross sectional area in square centimeters, and
38 = constant.

(2) *Example:* (fig 3–5)

Flange area = 2 × 1.3 × 12.7 = 33.02 sq cm or 33 sq cm
Web area = 1 × 28 = 28 sq cm
A (total) = 33 + 28 = 61 sq cm

$$K = \frac{A}{38} = \frac{61}{38}$$
$$K = 1.61 \text{ kg}$$

Use 1.816 kg (4 lb) TNT.

*b. Formula for other Steels.*

(1) *Formula:* $K = \frac{D^2}{14}$ where,

$K$ = Kilograms of TNT required,
$D$ = Diameter of section to be cut in centimeters and,
14 = constant.

(2) *Example:* Steel shaft is 5 cm in diameter.

$$K = \frac{5^2}{14} = \frac{25}{14}$$
$$K = 1.786 \text{ kg}$$

Use 1.816 kg (4 lb) of TNT.

*c. Table of Steel Cutting Charges.* Table B–2 gives the correct weight of TNT necessary to cut structural steel sections of various dimensions calculated from the formula $K = \frac{A}{38}$.

*Table B–2. Steel Cutting Charges (Metric).*

| Average thickness of section in centimeters | Kilograms of TNT for rectangular structural steel section of given dimensions | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Width of Section in Centimeters | | | | | | | | | | | |
| | 4.0 | 6.0 | 8.0 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 50 | 60 |
| 0.5 | .06 | .08 | .11 | .13 | .20 | .27 | .33 | .40 | .46 | .53 | .66 | .79 |
| 1.0 | .11 | .16 | .21 | .27 | .40 | .53 | .66 | .79 | .93 | 1.06 | 1.32 | 1.58 |
| 1.5 | .16 | .24 | .32 | .40 | .60 | .79 | .99 | 1.19 | 1.39 | 1.58 | 1.98 | 2.37 |
| 2.0 | .21 | .32 | .42 | .53 | .79 | 1.06 | 1.32 | 1.58 | 1.85 | 2.11 | 2.64 | 3.16 |
| 2.5 | .27 | .40 | .53 | .66 | .99 | 1.32 | 1.65 | 1.98 | 2.31 | 2.64 | 3.29 | 3.95 |
| 3.0 | .32 | .48 | .64 | .79 | 1.19 | 1.58 | 1.98 | 2.37 | 2.77 | 3.16 | 3.95 | 4.74 |
| 3.5 | .37 | .56 | .74 | .93 | 1.39 | 1.85 | 2.31 | 2.77 | 3.23 | 3.69 | 4.61 | 5.53 |

## B–5. Pressure Charges for T-Beams

*Formula:* $K = 48 H^2T$ where,

K = Kilograms of TNT required,
H = Height of T-beam in meters,
T = Thickness of beam in meters, and
48 = constant.

H and T are measured to nearest .10 meter, but never considered less than .30 meter.

*Note.* Minimum tamping of 30 centimeters is required. The value calculated must be increased by one-third, if untamped.

## B–6. Breaching Charge

*a. Formula:* $K = R^3MC$ where,

$K$ = Kilograms of TNT required,
$R$ = Breaching radius in meters (*b* below),
$M$ = Material factor, given in table B–3, which reflects the strength, hardness and mass of the material to be demolished (*c* below),
$C$ = a tamping factor, given in figure 3–13, which depends on the location and tamping of the charge (*d* below).

*b. Breaching Radius.* The breaching radius ($R$) is the distance in meters which an explosive charge must penetrate and within which all ma-

terial is displaced or destroyed. The breaching radius is rounded off to the next highest ¼-meter. For example, to breach a 2.9-meter concrete wall by placing a charge on one side, the value of $R$ in the formula $K = R^3MC$ is 3.0 meters.

*c. Material Factor.* The values of the material factor (M) for various types of construction are given in table B–3.

*Table B–3. Value of Material Factor M for Calculation of Breaching Charges (Metric).*

| Material | Breaching Radius | M |
|---|---|---|
| Ordinary earth | All values | 1.12 |
| Poor Masonry, Shale, Hardpan; Good Timber and Earth Construction | Less than 1.5 meters | 5.13 |
| | 1.5 meter or more | 4.64 |
| Good Masonry | .3 meters or less | 14.09 |
| Ordinary Concrete | Over .3 to less than 1 m. | 7.69 |
| | 1 to less than 1.5 meters | 6.41 |
| Rock | 1.5 to less than 2 meters | 5.13 |
| | 2 meters or more | 4.32 |
| Dense Concrete | .3 meters or less | 18.26 |
| First-class Masonry | Over .3 to less than 1 m. | 9.93 |
| | 1 to less than 1.5 meters | 8.33 |
| | 1.5 to less than 2 meters | 6.57 |
| | 2 meters or more | 5.61 |
| Reinforced Concrete | .3 meters or less | 28.19 |
| | Over .3 to less than 1 m. | 15.38 |
| | 1 to less than 1.5 meters | 12.81 |
| | 1.5 to less than 2 meters | 10.09 |
| | 2 meters or more | 8.65 |

*d. Tamping Factor.* The values of the tamping factor ($C$) depends on the location and tamping of the charge. No charge is considered fully tamped unless it is covered to a depth equal to the breaching radius. The values for $C$ are given in figure 3–13.

*e. Example:* Determine the amount of C4 (M112 blocks) required to breach a dense concrete pier 1.5 meters thick with untamped charges placed on the ground.

R = 1.5 meters
C = 3.6 (untamped, on ground, fig. 3–13.)
M = 6.57 (dense concrete, table B–3)
K = $R^3$ MC
K = $1.5^3 \times 6.57 \times 3.6$.
K = 79.8 kg of TNT per charge

$$K(C-4) = \frac{79.8}{1.34}.$$

K(C–4) = 59.6 kilograms of C–4
Use 106 M112 blocks of C – 4 (60.1 kg) per charge.

## B–7. Minimum Safe Distance

The following criteria gives the missile hazard distances at which personnel in the open are relatively safe from missiles created by bare charges placed in or on the ground (see also para 5–2).

*a.* For charges 12 kilograms or less, the minimum missile hazard distance is *300 meters.*

*b.* For charges from 13 to 195 kilograms, the distance at which personnel in the open are relatively safe from missiles is given in table B–4.

*c.* For charges over 195 kilograms, the minimum missile hazard distance is *750 meters.*

*Table B–4. Minimum Safe Distances (in the open) (Metric)*

| Kilograms of explosives | Safe distance in meters | Kilograms of explosives | Safe distance in meters |
|---|---|---|---|
| 1 to 12 | 300 | 100 | 604 |
| 15 | 321 | 110 | 625 |
| 20 | 355 | 120 | 642 |
| 25 | 380 | 130 | 660 |
| 30 | 405 | 140 | 676 |
| 40 | 445 | 150 | 692 |
| 50 | 480 | 160 | 707 |
| 60 | 510 | 170 | 722 |
| 70 | 537 | 180 | 735 |
| 80 | 561 | 190 | 749 |
| 90 | 583 | 195 and over | 750 |

# APPENDIX C

# USE OF LAND MINES, AERIAL BOMBS, SHELLS AND FOREIGN EXPLOSIVES AS DEMOLITION CHARGES

## C–1. Introduction

*a.* When land mines, aerial bombs, and shells are used as demolition charges, special precautions must be taken because of flying steel fragments. The use of such mines, bombs, and shells is generally uneconomical but may at times become necessary or desirable. Such material may be issued from captured or friendly supply stocks or, in the case of land mines, may be those recovered from enemy or friendly minefields. *In no case should unexploded dud shells or bombs be used for demolition purposes.*

*b.* When necessary, explosives of allied nations or those captured from enemy supply stocks may be used to supplement or used in lieu of standard explosive charges.

## C–2. Land Mines

*a. Safety Precautions.* Only defuzed mines should be used in demolition charges; as fused mines recovered from minefields may be sensitive because of near misses and may be detonated by even normal handling. The use of enemy mines salvaged from minefields or dumps is regulated by directives issued from headquarters of the theater concerned. United States and foreign land mines are described in detail in TM 9–1345–200 and TM 5–280.

*b. Charges.* In calculating demolition charges when using mines, only the explosive weight is considered. Normal explosive quantities may be used for cratering or pressure charges with mines; but, because of poor contact of the mine case against irregularly shaped objects, it may be necessary to increase cutting charges considerably. Test shots will determine the results to be obtained under given conditions. A list of antitank mines in current use by the United States and in current use or obsolete in foreign armies with their explosive weights is given below. Information, however, on the type of explosive used is not always available.

(1) *United States*

| *Type Mine* | *Explosive* |
|---|---|
| M15 AT (metallic) | 22 lb TNT |
| M19 AT (nonmetallic) | 21 lb TNT |
| M21 AT (metallic) | 10½ lb Comp. H6 |
| (2) *Foreign mines* | |
| (*a*) *Belgium* | |
| PRB–4 AT | 20 lb Hexogen |
| (*b*) *Communist China* | |
| Dual purpose No. 4 (metallic) | 4.5 lb TNT |
| (*c*) *Czechoslovakia* | |
| PT–Mi–K AT (metallic) | 11 lb TNT |
| PT–Mi–Ba AT (plastic) | 12 lb TNT |
| Na–Mi–Ba AT (plastic) | 5.3 lb Tritol |
| TQ–Mi AT (cardboard) | 11.5 lb TNT |
| (*d*) *Finland* | |
| M 36 AT (metallic) | 8 lb TNT |
| M 39 AT (metallic) | 8.8 lb TNT |
| (*e*) *France* | |
| M1948 AT (metallic) | 11.5 lb TNT or MD |
| M1948 plate charge AT (metallic) | 15.2 TNT or picric acid * |
| M1951 shaped charge AT (metallic) | 4 to 5 lb kexolite |
| M1951 AT (caseless) | 14.3 lb cast TNT |
| M1951 AT (plastic "grille") | 11 to 16 lb PETN |
| (*f*) *Japan* | |
| Model 63 Heavy AT | 24.2 lb Comp. B |
| (*g*) *Netherlands* | |
| Type 11 AT (metallic) | 9 lb |
| (*h*) *South Korea* | |
| Heavy AT mine (metallic) | 22 lb TNT |
| Type I dual-purpose (metallic) | 5.7 lb TNT |
| Type II dual-purpose (metallic) | 4.5 lb TNT |
| (*i*) *USSR* | |
| TMD–B AT (wooden) | 11 to 15 lb amatol, dynammonite TNT or picric acid * |
| TMN 46 AT (metallic) | 12.6 lb TNT |
| YaM–5 AT | 8 to 11 lb TNT or amatol |
| (*j*) *United Kingdom* | |
| Mark 4 GS AT (metallic) | 8.25 lb TNT |
| Mark 5 GS AT (metallic) | 4.5 lb TNT |
| Mark 5 HC AT (metallic) | 8.3 lb TNT |
| Mark 7 AT (metallic) | 19.6 lb TNT |

(* Picric acid corrodes metals, forming extremely sensitive compounds, easily detonated. Mines loaded with this explosive should not be handled except to move them to a safe disposal area for destruction.)

*c. Priming.* Land mines are detonated by means of a pound of explosive placed on the pressure plate. If large quantities of mines are to be fired simultaneously, several mines are primed to insure complete detonation. Detonation of a single mine normally detonates other mines in conact with it.

## C–3. Aerial Bombs

*a. Use.* General-purpose aerial bombs may be used satisfactorily as demolition charges but are more effective as cratering charges. Their shape makes them inefficient for demolitions requiring close contact between the explosive and the target. Precautions must be taken to avoid damage to installations and injury to personnel because steel fragments of the bomb case are thrown great distances. Before using a bomb, it must be positively identified as a general-purpose bomb.

*b. Charges.* The explosive content of bombs is approximately half their total weight. Table C–1 gives the weight of high explosive in various types of general-purpose bombs. Approximately 20 percent of the explosive power is expended in shattering the case.

*Table C–1. Explosive Contents of General-Purpose Bombs*

| Bomb | Total Weight (lb) | Explosive Weight (lb) |
|---|---|---|
| *Old series:* | | |
| 100-lb GP, AN–30A1 | 120 | 57 |
| 250-lb, GP, AN–M57A1 | 261 | 125 |
| 500-lb, GP, AN–M64A1 | 549 | 266 |
| 1,000-lb, GP, AN–M65A1 | 1,064 | 555 |
| 2,000-lb, GP, AN–M66A2 | 2,113 | 1,098 |
| *New series:* | | |
| 750-lb, GP, M117 | 823 | 386 |
| 3,000-lb, GP, M118 | 3,049 | 1,975 |
| *Low drag:* | | |
| 250-lb, GP, MK81 Mod 1 | 260 | 100 |
| 500-lb, GP, MK82 Mod 1 | 531 | 192 |
| 1,000-lb, GP, MK83 Mod 3 | 985 | 445 |
| 2,000-lb, GP, MK84 Mod 1 | 1,970 | 945 |
| *Low drag; Snakeye I:* | | |
| 250-lb, GP, MK81 Mod 1, Snakeye I | 300 | 100 |
| 500-lb, GP, MK82, Mod 1, Snakeye I | 560 | 192 |

*c. Priming.* Bombs under 500 pounds weight are detonated by firing a 5-pound explosive charge in good contact with the middle of the case. Bombs of 500 pounds or more are detonated by a 10-pound charge similarly placed. Fuses should not be positioned on the nose or tail. To insure detonation, large bombs should be primed separately.

## C–4. Artillery Shells (Nonnuclear)

Artillery shells are used for demolition only where a fragmentation effect is desired. Because of their low explosive content they are seldom used for other demolition purposes. The 105-mm howitzer HE shell, which weighs 33 pounds, contains only 5 pounds of explosive; while the 155-mm howitzer shell contains only 15 pounds. Shells up to 240-mm are detonated by 2 pounds of explosive placed in good contact with the case, just forward of the rotating band. To insure complete detonation, a charge should be placed on each shell. The M10 universal explosive destructor (para 1–58*a*) may be used to detonate projectiles or bombs that have 1.7- or 2-inch diameter threaded fuse wells. The booster cavities of bombs and large projectiles should be filled to the full depth by adding booster cups to the M10 destructor as required.

## C–5. Foreign Explosives

*a. Uses.* Foreign explosives may be used to supplement standard U.S. demolition charges or in certain cases used instead of them. Such explosives, however, should be used only by experienced demolition personnel and then only according to instructions and directives issued by theater commanders. The most common types of foreign explosives are listed in TM 9–1300–214.

*b. Priming.* Most foreign explosive blocks have capwells large enough to receive U.S. military blasting caps; however, these charges must be test fired with U.S. military blasting caps to insure positive detonation. In certain instances it may be necessary to initiate the explosives by use of a standard U.S. demolition block primed with a blasting cap.

# APPENDIX D

# EXPEDIENT DEMOLITIONS

## D–1. Use of Expedient Techniques

These techniques are not presented as a replacement for the standard demolition methods but for use by experienced blasters in special projects. Availability of trained men, time, and material will generally determine their use.

## D–2. Shaped Charges

*a. Description.* Shaped charges concentrate the energy of the explosion released on a small area, making a tubular or linear fracture in the target. Their versatility and simplicity make them effective against many targets, especially those made of concrete or those with armor plating. Shaped charges may be improvised (fig D–1). Because of the many variables, such as explosive density, configuration, and density of the cavity liner, consistent results are impossible to obtain. Thus experiment, or trial and error, is necessary to determine the optimum standoff distances. Plastic explosive is best suited for this type of charge. Dynamite and molten TNT, however, may be used as an expedient.

*b. Preparation.* Almost any kind of container is usable. Bowls, funnels, cone-shaped glasses (champagne glasses with the stem removed), and copper, tin, or zinc may be used as cavity liners; or wine bottles with a cone in the bottom (champagne or cognac bottles) are excellent. If none of these is available, a reduced effect is obtained by cutting a cavity into a plastic explosive block. Optimum shaped charge characteristics are—

(1) Angle of cavity = between 30° and 60° (most HEAT ammunition has a 42° to 45° angle).

(2) Standoff distance = 1½ × distance of cone.

(3) Height of explosive in container = 2 × height of cone measured from the base of the cone to the top of the explosive.

(4) Point of detonation = exact top center of charge. Cover cap, if any part of it is exposed or extends above the charge, with a small quantity of C4 explosive.

*Note.* The narrow necks of bottles or the stems of glasses may be cut by wrapping them with a piece of soft absorbent type twine or string soaked in gasoline and lighting it. Two bands of adhesive tape, one on each side of the twine or string, will hold it firmly in place. The bottle or stem must be turned continuously with the neck up, to heat the glass uniformly. Also, a narrow band of plastic explosive placed around the neck and burned gives the same result. After the twine or plastic has burned, submerged the neck of the bottle in water and tap it against some object to break it off. *Tape the sharp edge of the bottle to prevent cutting hands while tamping the explosive in place.*

## D–3. Platter Charge

This device utilizes the Miznay-Chardin effect. It turns a metal plate into a powerful blunt-nosed projectile (fig D–2). The platter should be steel (preferably round, but square is satisfactory) and should weigh from 2 to 6 pounds.

*a. Calculations.* Weight of explosive = approximately the weight of the platter.

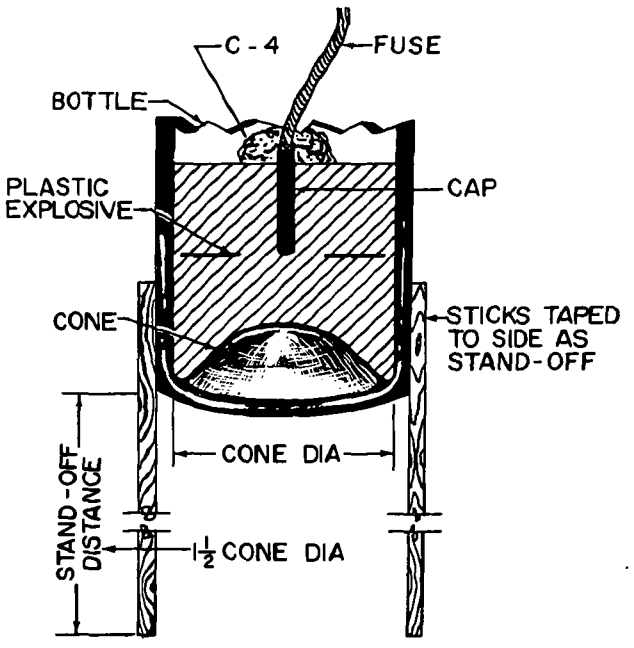



*Figure D–1. Improvised shaped charge.*

*b. Preparation.*

(1) Pack the explosive uniformly behind the platter. A container is not necessary if the explosive can be held firmly against the platter. Tape is acceptable.

(2) Prime the charge from the exact rear center. Cover cap, if any part is exposed, with a small quantity of C4 explosive to insure detonation.

(3) Aim the charge at the direct center of the target.

*c. Effect.* The effective range (primarily a problem of aim) is approximately 35 yards for a small target. With practice, a demolitionist may hit a 55-gallon drum, a relatively small target, at 25 yards about 90 percent of the time.

## D–4. Grapeshot Charge

This charge consists of a container, preferably a No. 10 can, projectiles (small pieces of steel), buffer material, an explosive charge, and a blasting cap. These are assembled as shown in figure D–3.

*a. Computation.* The weight of the explosive is approximately ¼ × the weight of the projectiles.

*b. Preparation.*

(1) Assemble the projectiles, a few inches of buffer material-earth, leaves, wood, felt, cloth, cardboard, etc., and the explosive charge. This should be C4, packed firmly.

(2) Prime the charge from the exact rear center. Cover the cap, if any part is exposed, with a small quantity of C4 to insure detonation.

(3) Aim the charge toward the center of the target.

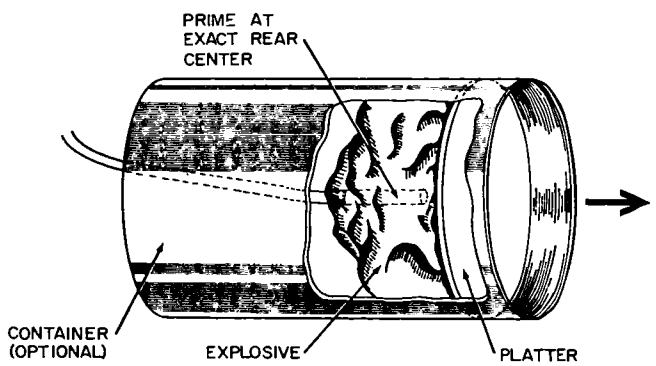



*Figure D–2. Platter charge.*

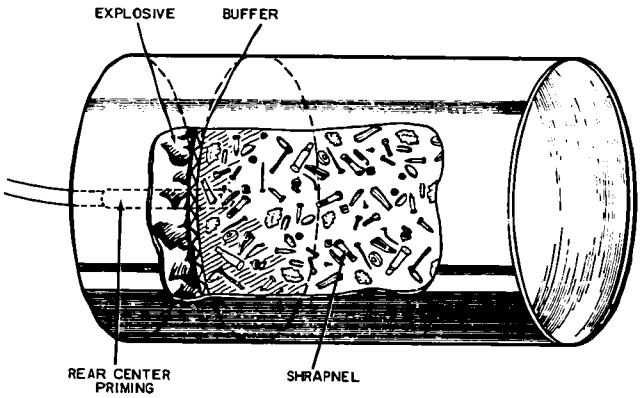



*Figure D–3. Grapeshot charge.*

## D–5. Dust Initiator

This device consists of an explosive charge (powdered TNT or C3; C4 will not properly mix with the incendiary), an incendiary mix (2 parts of aluminum powder or magnesium powder to 3 parts of ferric oxide), and a suitable finely-divided organic material (dust) or a volatile fuel such as gasoline called a surround. The dust initiator is most effective in an inclosed space, like a box car or a warehouse or other relatively windowless structure. At detonation, the surround is distributed throughout the air within the target and ignited by the incendiary material.

*a. Computation.*

(1) Charge size = 1 pound (½ explosive, ½ incendiary mix).

(2) Cover size = 3 to 5 pounds of each 1,000 cubic feet of target. The one-pound charge will effectively detonate up to 40 pounds of cover.

*b. Preparation.* Powdered TNT may be obtained by crushing it in a canvas bag. The incendiary mix must be thoroughly dispersed throughout the explosive. A great number of dust materials may be used as cover, among which are coal dust, cocoa, bulk powdered coffee, confectioners sugar, tapioca, wheat flour, corn starch, hard rubber dust, aluminum powder, magnesium powder, and powdered soap. If gasoline is used, 3 gallons is the maximum, as more will not disperse evenly in the air and thus give poor results.

## D–6. Improvised Cratering Charge

This charge is a mixture of ammonium nitrate fertilizer containing at least 33⅓ percent nitrogen and diesel fuel, motor oil, or gasoline, at a ratio of 25 pounds of fertilizer to a quart of fuel. The fertilizer must not be damp. From this mix-

ture, improvised charges of almost any size or configuration can be made. Proceed as follows:

*a.* Pour the liquid on the fertilizer.

*b.* Allow the mixture to soak for an hour.

*c.* Place about half the charge in the borehole. Then place the primer, a primed 1-pound block of TNT, and add the remainder of the charge. (Never leave the charge in the borehole for a long period, as accumulated moisture reduces its effectiveness.)

*d.* Detonate the charge.

## D–7. Ammonium Nitrate Satchel Charge

Although the cratering charge (para D–6) is excellent, it is suitable only for cratering. A more manageable charge may be used by mixing ammonium nitrate fertilizer with melted wax instead of oil. The primer is set in place before the mixture hardens.

*a. Preparation.*

(1) Melt ordinary paraffin and stir in ammonium nitrate pellets, making sure that the paraffin is hot while mixing.

(2) Before the mixture hardens add a half-pound block of TNT or its equivalent as a primer.

(3) Pour the mixture into a container. Shrapnel material may be added to the mixture if desired or attached on the outside of the container to give a shrapnel effect.

*b. Use.* Because the wax and fertilizer may be molded into almost any size or shape, it may be applied to a great many demolition projects with satisfactory effects.

# APPENDIX E

# POWER REQUIREMENTS FOR SERIES FIRING CIRCUIT

## E-1. Series Circuit

In demolition projects, electric blasting caps are connected in series and fired by an electric power source (blasting machine). A series circuit provides a single path for the electrical current which flows from one firing wire through each blasting cap to the next blasting cap and back to the other firing wire. A series circuit should not contain more than 50 blasting caps. The connection of more than 50 caps in a series circuit increases the hazard of breaks in the firing line or cap leads prior to the initiation of some caps.

## E-2. Ohm's Law

The amount of voltage necessary to detonate the blasting caps in these circuits is calculated by the use of the basic law of electricity, Ohm's Law—

$E = IR$

$E$ = electric potential, or voltage, expressed in volts.
$I$ = current, expressed in amperes.
$R$ = resistance, expressed in ohms.

## E-3. Electric Power Formula

Electrical power is computed by means of the following formula:

$W = I^2 R$

$W$ = electrical power, expressed in watts.
$I$ = current, expressed in amperes.
$R$ = resistance, expressed in ohms.

## E-4. Electrical Characteristics of Electric Blasting Caps

The current needed to fire military electric blasting caps connected in series should be at least 1.5 amperes regardless of the number of caps. The resistance of a military electric blasting cap is 2 ohms.

## E-5. Resistance of a Circuit

Resistance is computed to insure that the power source is adequate to fire all charges connected to the circuit. Both the blasting caps and the wire contained in a circuit contribute to the total resistance of that circuit. This resistance is computed from the individual resistances of the blasting caps and the wire. The resistance of the wire used in a circuit depends upon its size and the length. Table E-1 gives the resistance per 1,000 feet of various sizes of copper wire. The total resistance in a series circuit is the sum of the resistance of the various components of that circuit.

## E-6. Calculations for a Series Circuit

Complete calculations for any circuit involve the determination of the current (amperes), the voltage (volts), and the power (watts) needed to fire the circuit. Computation of the voltage and

*Table E-1. Resistance of Various Sizes of Copper Wire*

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Size of copper wire | | | |
| AWG (B&S) gage No. | Diameter (in.) | Length of wire to weigh 1 pound (ft. per lb.) | Resistance of 1,000 feet of wire (ohms per 1,000 ft.) |
| 2 | 3/10 | 5.0 | 0.2 |
| 4 | 1/4 | 7.9 | .3 |
| 6 | 1/6 | 12.6 | .4 |
| 8 | 1/8 | 20.0 | .6 |
| 10 | 1/10 | 31.8 | 1.0 |
| 12 | 1/12 | 50 | 1.6 |
| 14 | 1/16 | 80 | 2.5 |
| 16 | 1/20 | 128 | 4.0 |
| 18 | 1/25 | 203 | 6.4 |
| 20 | 1/30 | 323 | 10.2 |

of the power requires the determination of the resistance (ohms) in the system.

*a. Current Requirements.* The current required for a series-connected system of special electric blasting caps is 1.5 amperes, regardless of the number of blasting caps in the circuit.

*b. Resistance.* The resistance of the system is computed as described in paragraph E–5.

*c. Voltage Requirements.* Using Ohm's Law, *E-IR* (para E–2), the voltage needed is computed by multiplying the required current (1.5 amperes) by the resistance of the system.

*d. Power Requirements.* By means of the electrical power formula, $W\text{-}I^2R$ (para E–3), the number of watts of power needed may be found by multiplying the square of the current required ($1.5^2 = 2.25$) by the resistance of the system.

*e. Illustrative Problem.* Determine the current, voltage, and power required to detonate the blasting caps of a circuit consisting of 20 special electric blasting caps connected in series, and 500 feet of the standard 2-conductor, 18-gage firing wire.

(1) Current required = 1.5 amperes (*a* above)

(2) Resistance:

20 blasting caps = $2.0 \times 20 = 40$
1,000 feet No. 18 wire (table E–1) = 6.4
Total resistance = 46.4 ohms

*Note.* As 500-foot firing wire consists of 2 strands of No. 18 wire each 500 feet long, 1,000 feet of wire is used in the above computation.

(3) Voltage:

$E = IR$ (para E–2)
$E = 1.5 \times 46.4 = 69.6$ volts

(4) Power:

$W = I^2R$ (para E–3)
$E = 1.5^2 \times 46.4 = 2.25 \times 46.4 =$
$E = 1.5^2 \times 46.4 = 2.25 \times 46.4 =$
104.4 watts

## E–7. Calculated Voltage Drop

In each of the examples given above the voltage drop (*IR*) in the blasting circuit was calculated by the use of Ohm's Law. In practice, if the calculated voltage drop exceeds 90 percent of the available voltage, it is recommended that the resistance of the circuit be decreased or the voltage be increased.

## E–8. Capacity of Power Sources

*a. Determining Capacity of Power Sources.* It is possible to determine from the nameplate amperage and voltage rating whether the power source is suitable for firing an electric circuit computed by the above methods. Frequently, however, the size of a circuit that may be fired with current from a given power source may be determined by consulting table E–2 which gives the maximum capacities of some power sources. If it is necessary to calculate the capacity of a given generator from the nameplate data, proceed as follows:

(1) Divide 90 percent of the voltage of the generator (para E–6) by the total amperage of the circuit, 1.5 amps, to determine the maximum resistance in ohms that may be in the circuit.

(2) Subtract the total wire resistance from the maximum allowable circuit resistance of caps to determine the maximum allowable resistance of the caps in the circuit.

(3) To calculate the maximum number of caps, divide the allowable resistance of the caps in the circuit by the resistance of one cap (2.0 ohms).

*b. Illustrative Problem.* Determine the number of military electric blasting caps in series that may be fired by a 220-volt, 13½ ampere generator using 500 feet of 20-gage connecting wire.

(1) Allowable resistance of circuit = $\frac{(0.90)(220)}{(1.5)} = 132$ ohms (para E–6 and E–7).

(2) Resistance of firing wire = $\frac{(10.2)(500)}{1{,}000} = 5.1$ ohms (table E–1).

(3) Allowable resistance of caps for a series circuit = 132 − 5.1 = 126.9 ohms.

(4) Number of blasting caps allowed in the series circuit = $\frac{126.9}{2.0} = 63.4$ or 63 caps (*a*(3) above).

*c. Use of Storage Batteries and Dry Cells.* The size of a circuit that may be fired by a battery or dry cell may be determined by following the same procedure as that outlined in *a* (1) through (3) above.

***Caution.*** **For safety, disconnect the battery terminal prior to disassembly of the equipment where there is danger from shorting across the battery circuit. In reassembly, make the battery terminal connection last.**

*Table E–2. Maximum Circuit Capacities of Various Power Sources*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| Circuit design | Total number of caps in circuit | Power source | | | | | | | |
| | | 10-cap blasting machine | 30-cap blasting machine | 50-cap blasting machine | 1½-kw portable generator 115-volt, 13½-amp | 3-kw portable generator, 115-volt 26-amp | 5-kw portable generator, 115-volt 43½-amp | 3-kw portable generator, 220-volt 13½-amp | 5-kw portable generator, 220-volt 22½-amp |
| | | The circuits below are connected by one 500-foot standard two-conductor firing reel | | | | | | | |
| 1 10 caps in continuous series. | 10 | X | X | X | X | X | X | X | X |
| 2 30 caps in continuous series. series. | 30 | ---- | X | X | X | X | X | X | X |
| 3 50 caps in continuous | 50 | ---- | ---- | X | ---- | ---- | ---- | X | X |

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By Order of the Secretary of the Army:

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